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ART. XXXI.—*Observations on the Zodiacal Light; with an inquiry into its Nature and Constitution, and its Relations to the Solar System;* by DENISON OLMSTED, Professor of Natural Philosophy and Astronomy, in Yale College.

Read before the American Association for the Advancement of Science, at the Annual Meeting at Albany, August, 1851.

I SUBMIT to the Association a series of observations on the Zodiacal Light, made by me at Yale College from 1833 to 1839, upon the basis of which I propose to offer a new description of this mysterious phenomenon, and a brief inquiry into its nature and constitution, and its relations to the solar system. Particularly, I propose to inquire whether or not it is the origin of the meteoric showers of November and August.

Various circumstances conspire to interrupt the continuity of a series of observations on the zodiacal light; among which are the following:—

1. The comparatively few nights in the year when, in our climate, the sky is cloudless, and the atmosphere sufficiently clear to afford good observations on a light so feeble and diffuse.

2. The low angle which the zodiacal light makes with the horizon for the greater part of the year while it is visible.

3. The presence of the moon, which entirely effaces it; and, occasionally, for long periods, the presence of Venus or Jupiter, and sometimes of both planets. The light of Venus, especially, is often so bright, and the planet is so situated in the midst of the zodiacal light, as greatly to interfere with observations. Hence, a

number of years are necessary of diligent attention to the phenomena of this light, in order to become well acquainted with its habitudes and laws. Nor can I pretend to have made the best possible use of the opportunities afforded for viewing it, during the six years that my attention was directed to it. On the contrary, my observations were often interrupted by ill health, and other causes beyond my control. Still, they were sufficient to convince me that my previous knowledge of this body was exceedingly defective, and my notions of it very erroneous; and the same may justly be said of most or all of the descriptions and graphic representations of it given in works of science.

I will therefore, first, attempt an accurate *description* and *representation* of the zodiacal light.

Since the direction of this body is oblique to the circles of diurnal revolution, and since it appears only immediately before or immediately after the sun, and therefore more or less of it falls within the twilight, consequently, its appearances are very different in different latitudes, being seen best of all in the tropical regions, where its direction always makes a high angle with the horizon, and where the twilight is short; and being scarcely visible in such high latitudes as London and Edinburgh, except near the time of the equinoxes. Hence British writers who have attempted a description of it, have usually given one that is altogether vague and inaccurate. The lower latitude of our place of observation (41° 18′ 30″) affords a much better view of it, and my description and representation of it will conform to its appearance at this latitude.

I learn from my friend, Prof. Dana, that while with the Exploring Expedition in the torrid zone, he seldom failed of seeing the zodiacal light morning or evening, when not prevented by some of the causes before enumerated; but during the summer months in our climate, we hardly see it at all. At the beginning of autumn we look for it in the morning sky, and at the end of autumn in the evening sky. The state of the atmosphere most favorable for seeing it at its minimum intensity, is that peculiarly transparent condition which either precedes or follows a copious rain. The presence of a black cloud, also, near the horizon, frequently enables us, by contrast, to see more distinctly the faint diffusive light of the upper portions. With these advantages we may unite that of fixing one eye on a darker portion of the heavens a few degrees to the right or left, and looking askance with the other eye over the region of the object sought. This last expedient will usually be found useful for fixing its exact boundaries, in its various stages of intensity.

Although, as was first remarked by Mr. E. C. Herrick, faint traces of the zodiacal light may be seen in the northeast early in August, yet it will hardly be obvious to common observation be-

fore the latter part of September. I quote from my record for September 25th, 1835:—

Observed the zodiacal light from 3 to 4½ o'clock, A. M. Very faint. Seen only by fixing the right eye on the region of Canis Major, and carrying the left eye along the ecliptic. Covers Regulus and the cluster in Cancer, and terminates a little south of Castor.

The earliest distinct view I have obtained of this body in the *evening* sky, was on the 21st of November, 1837, when I have the following record:—

Have constantly searched for the zodiacal light in the evening since the 13th inst. Imagined that that part of the milky way where this light would cross it was more luminous than common, but the light is ambiguous on account of the presence of Venus. But this evening examined in company with three of my astronomical pupils, all distinguished for acuteness of vision. At 7 o'clock, Venus being near the horizon and hid behind a cloud, we could severally define the boundaries of the zodiacal light. By fixing the right eye on the milky way near Altair, and the left eye near the head of Capricornus, we could discern a pyramid less bright than the milky way, but still sufficiently distinct to be sure of its presence. Its upper edge grazed α and μ Capricorni and β Aquarii, its vertex reaching to the right shoulder of Aquarius. Light very feeble and diffuse, but the triangular space between it and the milky way, embracing the Dolphin, perceptibly darker. Elongation from the sun 90°.

As a description of the zodiacal sufficient to guide the observer I will offer the following: From the middle of September until the latter part of November, he will confine his attention to the *morning* sky. An hour and a half before daybreak (which is at that season of the year, in our climate, about 4 o'clock,) he will first discern a feeble, diffuse, and scarcely visible light, of a pyramidal figure, extending from the horizon upward through the zodiac to Gemini, covering Regulus and Presepe, and terminating a little south of Castor. Near the horizon its material is usually mixed up with the vapors that prevail there, so as to prevent its forming a definite boundary at its base; but from an altitude of a few degrees above the horizon, the light gradually declines until it fades into nonentity. Along the central part of the pyramid the illumination is greater than at the borders. From the greater length and amplitude revealed to us by circumstances peculiarly favorable for observation, we have reason to think that, on ordinary occasions, we do not see the whole of the body, but that it really extends further than its visible boundaries, both in length and breadth. If the observer continues to watch this body from the middle of September onward through the month of October to the middle of November, he will perceive that the vertex or visible terminus moves along through the order of the signs, and nearly at the same rate with the sun, appearing, on the

25th of October, to occupy the space south of Denebola in the tail of the Lion, terminating a little above Regulus. From this time until the middle of November it appears nearly stationary, ascending from the horizon to the constellation Leo, in some part of which it terminates, the vertex varying somewhat in altitude with the condition of the sky. After the 13th of November, the light fades in the morning sky, contracts in dimensions, and soon becomes stationary and then retrograde with respect to the sun, proceeding eastward no further than γ Virginis, a point which it reaches by the 26th of November, having at this time an elongation of only 60°, whereas a fortnight before the elongation was 90°. As the sun advances in the ecliptic, while the light appears nearly stationary, the elongation on this side continues to diminish, as well as the dimensions and the illumination, until early in January, after which it is scarcely seen in the east until August.

The foregoing general statements are supported by observations taken at different times through the period of six years before mentioned, a few of which I extract from my records:—

Nov. 26, 1837.—This morning about daybreak, saw the zodiacal light—very bright and distinct, but elongation only 60°.

Nov. 28.—Commenced observations at 5 o'clock. Zodiacal light brighter than usual in preceding years at this season, but the vertex appears nearly stationary in Gamma Virginis.

Dec. 5.—Zodiacal light visible this morning as early as 3 o'clock. Not quite so bright as on the 28th of November, but increased in brightness from 3 o'clock till daybreak—vertex still in γ Virginis.

Dec. 9.—Examined the eastern sky from 4^h 30^m till daybreak. Very cold and clear. Zodiacal light much less bright than on the 5th. Width also less; when I first went out could scarcely see it. Became distinct by 5 o'clock, half an hour before daybreak. Yet much feebler than it was ten days ago. Contracted between Spica and Theta Virginis, 4° north of Spica, whereas a few days since the border grazed this star.

Jan. 18, 1837.—Zodiacal light very diffusive and ill-defined. Seen after this no more in the east.

We will now introduce the observer to the western sky. Here the zodiacal light first comes into view, so as to be distinctly defined, about the 21st of November, at which time it lies far in the southwest, crosses the milky way, the head of Capricornus, and has its vertex near the right shoulder of Aquarius, with an elongation from the sun of full 90°. From this time it climbs rapidly upwards, until by December 2d it reaches nearly to Algenib in the equinoctial colure, having an elongation of more than 100°. By about Christmas the vertex reaches almost to Alpha Arietis, having an elongation of towards 120°. It becomes nearly stationary through the month of January, but in

February and March it moves slowly onward through Taurus to Gemini, beyond which it scarcely advances. The accompanying diagram (Pl. II,) is intended to represent the general appearance of the zodiacal light, when seen under favorable circumstances near the time of the vernal equinox. It is seen of a pyramidal form with a broad base resting on the horizon. Its northern border grazes the bright star Algenib in Pegasus, passes south of Alpha Arietis seven or eight degrees, and about two degrees south of the Pleiades. Along its southern boundary we recognize the stars in the mouth and neck of the Whale, and still higher, Aldebaran, the Hyades, and the horns of the Bull. The successive positions attributed to the zodiacal light from the time of its earliest appearance in the western sky, the 21st of November, to the vernal equinox, are not absolutely uniform, but they still correspond to observations made during the six years before mentioned, as will appear from a few extracts from my record book. I have already recited the observation of November 21st, 1837, when the return of the body to the western sky was first recognized.

Nov. 26, 1837.—Light feeble, Venus being very bright; but seen after Venus was set, reaching nearly to the Fish south of Pegasus. Elongation 100°.

Dec. 2.—New moon begins to interfere with observations; but this evening the zodiacal light was visible after the moon was set. Covers the Pentagon in Pisces and reaches beyond it. Elongation 110°.

Dec. 18.—Early part of the day a violent rain and high wind. Cleared off towards night. Zodiacal light very bright, reaching at least to Alpha Arietis—nearly as bright as the milky way. Elongation 120°.

It ought to be remarked that the phemonena of this body were peculiarly striking in the autumn and winter of 1837, and the observations made this year show a greater intensity of light and a greater elongation from the sun than those of corresponding dates in 1835 and 1836.

Dec. 21, 1835.—This evening atmosphere very transparent. Zodiacal light very conspicuous, reaching nearly to Algenib, though quite faint towards the vertex. Elongation 90°.

Dec. 28, 1837.—Night favorable. Appeared to me not to reach quite so far eastward as it did a few nights since—certainly not beyond the equinoctial colure. Could not be certain much further than the pentagon of stars in Pisces. Elongation 75°.

February 7.—Zodiacal light very conspicuous since the last moon, but has advanced eastward very little since Christmas, still reaching only to Alpha Arietis. Elongation 75°.

Feb. 24.—First night since the moon has been away. Sky favorable for observation. Zodiacal light bright and well defined, its axis nearly in the ecliptic. Reaches to the space between Aldebaran and the Pleiades. Elongation 85°.

March 26.—Zodiacal light very bright, reaching above the Pleiades, which are a little north of the axis. Elongation 60°.

March 29.—Light more faint. Elongation 60°. Vertex near the ecliptic.

April 6.—Light fading rapidly. Very diffuse.

May 1.—Last night a very plentiful rain after a series of warm days. To-day air keen and sky very clear. This evening zodiacal light remarkably distinct, (for this season of the year,) being discernable much nearer the horizon than common, and reaching further eastward among the stars than I ever observed it before, namely, into the neighborhood of Castor and Pollux. Elongation 60°, but presumed to be much greater than it would be but for the extraordinary transparency of the atmosphere.

May 10, 1834.—Zodiacal light seen for ten minutes after twilight ceased—say till ten minutes after nine. Reached to Castor, but very diffuse. Elongation 57°.

Seen no more in the west till the latter part of November.

To present at one view the various elongations from the sun, observed from Nov. 21st to May 10th, the result is as follows:—

1. Nov. 21st,	Elongation,	90°	7. Feb. 7th,	Elongation,	75°
2. Nov. 26th,	"	100°	8. March 29th,	"	60°
3. Dec. 2d,	"	110°	9. April 6th,	Light rapidly fading.	
4. Dec. 18th,	"	120°	10. May 1st,	Elongation,	60°
5. Dec. 21st,	"	90°	11. May 10th,	"	57°
6. Dec. 28th,	"	75°			

From this tabular view it appears that when the body first came into view, on the 21st of November, it extended about 90° eastward of the sun; that its elongation increased rapidly from this period, being five days afterwards 100°, in six days more 110°, and in fourteen days after this 120°, which is the greatest elongation I have ever noticed; and being at the same time about 60° westward of the sun, its whole extent in longitude was 180°.

I have, in a few instances, remarked what was apparently a sudden and remarkable expansion of the zodiacal light, a circumstance more than once noted by Cassini. My record for November 21st, 1838, is as follows:—

At 5 A. M., about 20 minutes before twilight, the zodiacal light was very large, extending in breadth from Corvus to Arcturus. Never saw it so broad before. More inclined towards the south than usual, its vertex passing one or two degrees to the south of Regulus.

Whether this extraordinary enlargement in breadth, implying a space of more than 40° was owing to a change in the body itself, or to some unusual atmospheric refraction, or the accidental presence of an aurora borealis, it is impossible for me to decide.

It is well known that the great French astronomer, Dominique Cassini, was the first to direct the attention of astronomers towards the zodiacal light, and that he made numerous observations on it extending from 1683 to 1688 inclusive, which are pub-

lished in the eighth volume of the Memoires of the French Academy, together with observations on the same phenomenon made at Geneva by a friend of his, M. Fatio. An elaborate digest of these records are made by Mairan in his celebrated Treatise on the Aurora Borealis, including also a few observations of his own, and of several other philosophers. It is interesting to compare these ancient observations with such as we have been able to make at corresponding times of the year; and having made this comparison in numerous instances, I feel able to say that *the zodiacal light, in the main, is the same thing that it was in the days of Cassini and Mairan*, being subject to similar variations at different seasons of the year and in different states of the atmosphere. I shall avail myself of such aid as I can obtain from this and every other source in the remaining parts of this essay.

NATURE AND CONSTITUTION OF THE ZODIACAL LIGHT.

1. *Length.*—The extreme portions of this body sometimes extend beyond the earth's orbit. It is obvious that, at an elongation of 90°, it must reach a tangent drawn to the earth's orbit at the place of the spectator; and if it reaches beyond that tangent, as is sometimes the case, it must of course extend beyond the earth's path. According to one of our observations, on the 18th December, 1837, its elongation was 120°.

The variable apparent elongation to which this phenomenon is subject is more or less influenced by three causes: the state of the atmosphere, the inclination of its line of direction to the horizon, and the length of the twilight. In order to eliminate the effect due to atmospheric changes we require numerous series of observations, continued through successive years, and, if possible, instituted at long intervals of time. The mean of such an assemblage of observations would exhibit results nearly free from the effects of accidental variations in the transparency of the atmosphere. Since the axis of the zodiacal light does not deviate far from the ecliptic, we may imagine it to be represented by a portion of that circle on the artificial globe, and we shall easily see that since its inclination to the horizon varies between twenty-five and seventy-two degrees, being twenty-five at the vernal equinox, (twenty-five degrees with the eastern and seventy-two degrees with the western horizon,) this cause must greatly affect the degree of intensity of the zodiacal light. The same must obviously be the case with the variations in the length of twilight, being an hour and a half after sunset at the vernal equinox, and two hours and a quarter after sunset at the summer solstice. But were these causes, combined, the only or the chief reason why the apparent elongation of the zodiacal light from the sun is greater at one time than at another, then, since at the vernal equinox the elevation above the horizon is at its maximum and

the duration of twilight at its minimum, the apparent elongation ought to be greatest of all; whereas it is then only 60°, while from the 21st of November to the 18th of December, 1837, we found it increase from 90° to 120°, and this at a season of the year when the elevation above the southern horizon is near its minimum, and the duration of twilight is longer than before. Nor is this an anomalous fact; the elongation has uniformly appeared greater in the west, during the months of December and January, than during March and April. Again, at the winter solstice the elevation is much greater in the morning than in the evening; but the light is far more conspicuous in the west than in the east.

2. *Direction.*—The generai direction of the zodiacal light is, as its name imports, from the sun along the zodiac. Cassini and Mairan thought that its axis lay nearly or quite in the plane of the solar equator, making an angle with the ecliptic of seven and a quarter degrees; and, accordingly, that its nodes must be in the part of the ecliptic which the earth traverses in June and November. But Cassini himself remarked, that the direction of the axis is not always the same. On several occasions the vertex appeared to him to veer to the northward of its previous direction, so that, while it would at one time just *graze* Alpha Arietis on its northern border, shortly afterwards that star would be wholly within it. Before I had met with these statements in Cassini, I had several times remarked the same changes in the direction of the axis, the vertex sometimes lying in the ecliptic itself. Nor, as I think, will the observations warrant the conclusion that the axis of this body cuts the sun and consequently lies across the ecliptic in the plane of a great circle. On the 19th of January, 1835, the northern border was 8° south of Castor, and the vertex directed to a point south of the Pleiades. Consequently, its axis could not have been far from the ecliptic. But, on the 20th of March, the vertex reached above the Pleiades, and the axis had perceptibly veered northward from the ecliptic. These observations taken in connection with those of Cassini, indicate that the supposed relation of this body to the solar equator is not constant. In the year 1843, M. Houzeau published an article in the Astronomische Nachrichten in which he investigated the plane of symmetry of the zodiacal light from data derived from a comparison and digest of all the observations he could collect. He makes the inclination less than half that of the solar equator, and the place of the nodes of course quite different from that assigned to them by Cassini.

If then, as is demonstrated by Houzeau, the normal place of the axis gives it an inclination of only about $3\frac{1}{2}°$, the great occasional deviations from this direction confirm our remark, that the course of the zodiacal light along the zodiac is not always the same but is subject to vary with the seasons of the year.

3. *Motions.*—The zodiacal light sometimes moves forward in the order of the signs, it is sometimes stationary among the stars, and sometimes retrograde. Beginning with morning observations in August, and noting its positions from day to day, we see it first stretching across the middle of the constellation of the Twins.* The vertex moves slowly along through the constellations Gemini, Cancer, and Leo, being, on the 13th of November, a little east of Gamma Leonis,† having, in three months shifted its place eastward nearly three signs, and consequently nearly kept pace with the sun in its annual revolution, maintaining an average elongation from that body of 90 degrees. After the middle of November its light fades away in the east, its vertex becomes nearly stationary and of course its elongation westward of the sun diminishes, until the early part of January, when it is hardly visible at all in the morning sky. In the mean time, this light has been rapidly rising in the evening sky, and to this we will next direct our attention.

We have seen that about the 25th of November its upper portions reach beyond Capricornus, its vertex extending to the right arm of Aquarius. From this time it moves onward, sometimes more rapidly than the sun, but with an average elongation of 90°, until about the 24th of February, when it reaches a point a little south of the Pleiades. From the latter part of February, its progress eastward has seemed to me slower than before, hardly gaining one sign for the next three months, scarcely ever being distinctly visible beyond Castor, although neither the want of elevation above the southern horizon, nor the length of the twilight, would prevent its being seen beyond this if in reality it existed there. Finally, early in April it rapidly fades away, and soon after the first of May disappears altogether.

These facts respecting the zodiacal light are derived chiefly from my own observations, made and recorded at different times during the six years following 1833; but on comparing them with the observations of Cassini made towards 170 years ago, a near correspondence will be found between them; and the same will be the case if the comparison be made with the tabular view of observations collected from various authorities, as given by Houzeau in 1843.

In some cases, the apparent progress of this body through the signs corresponds so nearly to that of the sun, as to suggest the idea that it is something attached to the sun, and has an apparent motion due to the same cause, namely, the motion of the earth in its orbit. In other cases, however, its movements are too sudden and too unlike those of the sun to permit such a conclusion.

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* Above this point the light is blended with that of the milky way.

† Cassini placed it in 1686 at χ Leonis.

At one time, as we have seen, its elongation from the sun increases rapidly from 90° to 120°; at other times it becomes for considerable periods stationary among the stars, and even retrograde; facts which seem to imply motions of its own independent of the sun and the earth; and such motions in any body thus situated, though they might be greatly modified by perspective, can hardly be any other than motions of revolution. On this subject La Place has the following remarks, at the end of his chapter "on the figure of the atmosphere of the sun."

(1.) "This atmosphere can extend no further than to the orbit of a planet, whose periodical revolution is performed in the same time as the sun's rotary motion about its axis, or in twenty-five days and a half. Therefore, it does not extend so far as the orbits of Mercury and Venus, and we know that the zodiacal light extends much beyond them.

(2.) "The ratio of the polar to the equatorial diameter of the solar atmosphere, cannot be less than two-thirds, and the zodiacal light appears under the form of a very flat lens, the apex of which is in the plane of the solar equator. Therefore, the fluid which reflects to us the zodiacal light, is not the atmosphere of the sun, and since it surrounds that body, it must revolve about it according to the same laws as the planets: perhaps this is the reason why its resistance to their motions is insensible."

4. *Material.*—The matter of which the zodiacal light is composed, presents many analogies to that of comets. In its visible form, in its direction with respect to the sun, in its very shade and color, in its increasing density towards the sun, in its transparency which, as in comets, is such as to permit small stars to be seen through almost every part of it: in all these respects we recognize a great resemblance between the zodiacal light and the tails of comets. We are at least authorized to say that it is a "nebulous body."

From all the foregoing considerations on the nature and constitution of the zodiacal light, we infer, then, that it is a nebulous body, revolving around the sun in an orbit but slightly inclined to the ecliptic.

I proposed finally to inquire *whether or not the zodiacal light is the origin of the meteoric showers of November and August, and especially those of November.*

It may be known to some present that after the great meteoric shower of November 13th, 1833, I published in the American Journal of Science some observations on the phenomena and causes of that remarkable exhibition of shooting stars, in which I came to the conclusion that they proceeded from a nebulous body revolving about the sun, and, at its aphelion, approaching very near to that part of the earth's orbit through which the earth passes on the 13th of November. At the conclusion of the

essay, I suggested the possibility that the zodiacal light might be the body in question. I was reluctant, however, to insist on such a connection, because the existence of the nebulous body was inferred from evidence wholly independent of the zodiacal light, and even before the zodiacal light was thought of. In fact, at that time I had very vague ideas respecting this light, as something that appears in the west after twilight about the time of the vernal equinox, but I did not even know that it was ever visible at the period of the year when the November meteors occurred; for at that time I had never read either the observations of Cassini on this body, or the treatise of Mairan on the Aurora Borealis, where so much is ascribed to its agency in the production of this latter phenomenon. Nearly twenty years have since elapsed, and I have had sufficient opportunity to observe the zodiacal light, and to reflect on the question of its possible connection with the meteoric showers of November and August. The result is, an increasing conviction of such a connection. I may here remark that the first idea of such an origin of the November meteors, is now generally ascribed by European writers to M. Biot. It may be proper, however, to state that the paper in which M. Biot first mentions the subject, is an essay read before the French Academy soon after the meteoric shower of November, 1836, three years after my paper was published. M. Biot does, indeed, favor the idea that these showers of meteors have their origin in the zodiacal light; but in noticing the views which I had published, respecting the cause of the meteoric shower, which he did me the honor to review at some length and in a manner very encouraging to myself, he distinctly stated that I had in my paper suggested the idea that the zodiacal light might possibly be the very nebulous body in question.

I am aware that the opinions I have formed differ widely from those entertained by many members of this Association, whose eminent talents and great success in the investigation of truth entitle them to the highest deference; but, should I fail of convincing them of the correctness of my views, I still indulge the hope that I may secure increased attention to a natural phenomenon, which appears to me to have important relations to our solar system, as well as to several of the most sublime and mysterious phenomena of nature.

In the paper which I published in the American Journal of Science in the year 1834, on the cause of the great meteoric shower of November 13th, 1833, I inferred the existence, in the planetary spaces, of a nebulous body revolving around the sun, the extreme portions of which on the 13th of November lay over or across the earth's orbit, in such a manner that the earth passed through it, or at least near enough to it to attract portions of it into its atmosphere, where they took fire and exhibited the

phenomena of shooting stars. As the leading steps by which I arrived at this conclusion, after an extensive induction of facts, were very brief and simple, I may be permitted to repeat them here. I argued thus: If all the meteors which fell on this occasion (which were in vast numbers, and some of them proved to be bodies of comparatively large size,) had been restored to their original position in space, they would of themselves have composed a nebulous body of considerable extent. But, since the same shower had been several times repeated without any apparent exhaustion of the nebulous body, it was inferred that only small portions of that body came down to us, such as constituted its extreme parts which approximated nearest to the earth; and various reasons induced the belief that the nebulous body itself was one of very great extent. It was a striking fact that the earth had, during several preceding years, fallen in with this body at exactly the same part of its orbit. Now, since it is impossible to suppose that a body thus situated, and consequently subject to the sun's attraction, could have remained at rest in that part of the earth's orbit while the earth was making its revolution around the sun, the conclusion was that the nebulous body itself has a revolution around the sun, and a period of its own. Since the earth and the body met for several successive years at the same point of the ecliptic, that period must obviously be either a year or less than a year. It could not be more than a year, for, in that case, the body would not have completed its revolution so as to meet the earth at the same point for successive years. Its period might be a year, and it might be less than a year provided the time was some aliquot part of a year, so as to make it revolve just twice or three times, &c., while the earth revolves once. The time being given we easily find the major axis of the orbit by Kepler's third law. On trying so short a period as one third of a year, it gives a major axis too short to reach from the sun to the earth, and hence it was inferred that the body could not have so short a period as four months, since it would never in that case reach the earth's orbit, even at its aphelion. A period of six months was found to be sufficient, and this was accordingly assumed at first to be the time, although the possibility that the period might be a year was distinctly admitted. But, extensive as I even then believed the nebulous body to be, I had formed very inadequate notions of its real extent, for this may clearly be sufficient to reach from the sun to the earth, and thus to correspond in dimensions to the zodiacal light; and since the center of gravity of this body may be far within the earth's orbit, so its orbit may, even at its aphelion, be distant from the earth, and yet the extreme portions of the body may reach beyond the ecliptic. It would, therefore, be entirely consistent with my original views, to assign to a nebulous body of such an extent as

that of the zodiacal light, a period as short as one third of a year, or even less.

I do not assert positively that the zodiacal light is the veritable body which produces the meteoric showers of November and August. Before such an hypothesis can be proved to be true or false, with certainty, a greater number of precise observations continued through a series of years, would require to be made, and a careful comparison instituted between the hypothesis and the facts. Should the zodiacal light be found at last incompetent to explain the periodical meteors, the existence of a nebulous body, as inferred from a full survey of the facts in the case of the meteoric shower of November 13th, 1833, independently of all hypothesis, will still be true. But, with great deference, I submit to the Association, the following *presumptions* in favor of the opinion that the zodiacal light is the nebulous body which produces the meteoric showers of November.

1. The zodiacal light, as we have found in our inquiry into its nature and constitution, is a *nebulous body.*

2. It has a *revolution* around the sun.

3. It reaches beyond and *lies over the earth's orbit*, at the time of the November meteors, and makes but a small angle with the ecliptic.

4. Like the "nebulous body," its periodic time is *commensurable* with that of the earth, so as to perform a certain whole number of revolutions while the earth performs one, and thus to complete the cycle in one year, at the end of which the zodiacal light and the earth return to the same relative position in space. This necessarily follows from the fact that at the same season of the year it occupies the same position one year with another, and the same now as when Cassini made his observations nearly one hundred and seventy years ago.*

5. In the meteoric showers of November, *the meteors are actually seen to come from the extreme portions of the zodiacal light*, or rather a little beyond the visible portions; and the same was true of the radiant point of the meteors, (when watched, as it was by Mr. Fitch,† from Oct. 16th to Nov. 13th, 1837,) namely, that the radiant always keeps the same relative position with respect to the vertex of the zodiacal light, being with that vertex in Gemini, in the month of October, and travelling along with it through the Constellation Cancer, and into Leo, where it was on the morning of the meteoric shower. Observations, so far as they have been made, indicate a similar relation between the meteors of August and the extreme portions of the zodiacal light.

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* For the first suggestion of this analogy, I am indebted to one of my former pupils, Mr. Hubert Newton.

† Amer. Jour, Sci., xxxiii, 386.

These five propositions I offer as so many *facts* established by observation. Most of them appear in the original paper of Cassini on the zodiacal light; others may be seen in the tabular collection by Houzeau of all the known observations made at different periods; a few, not noted by others, have been added by myself. For the inferences here made respecting the connexion of this body with the periodical meteors, I alone am responsible.

ART. XXXII.—*Cultivation of Nutmegs and Cloves in Bencoolen;** by Dr. LUMSDAINE.

THE mode of culture adopted in the different nutmeg plantations is nearly the same. The beds of the trees are kept free from grass and noxious weeds by the hoe, and the plough is occasionally run along the interjacent spaces for the purpose of eradicating the Lallang (Andropogon caricosum) which proves greatly obstructive to the operations of agriculture. The trees are generally manured with cow dung and burnt earth once a year in the rainy season, but the preparation of suitable composts and their mode of application are but imperfectly understood. The pruning knife is too sparingly used; very few of the planters lop off the lower verticels of the nutmeg trees or thin them of the unproductive and straggling branches.

The site of a plantation is an object of primary importance, and doubtless the alluvial grounds are entitled to preference from the acknowledged fertility of their soil, and its appropriate organization and capability of retaining moisture, independent of the advantage of water carriage. Several of the nutmeg trees of the importation of 1798 at Moco Moco, are placed in soil of this description; although never manured they are in the highest state of luxuriance and bear abundantly; and I have been informed by a gentleman recently arrived from that station, that the stem of one of them measures 38 inches in circumference. Some of the trees in my own experimental garden, corroborate the truth of this assertion; one of these blossomed at the early age of two years ten months and a half, a degree of precocity ascribable solely to its proximity to the lake which forms the southern boundary. This was the first tree that blossomed of the importation of 1803, which consisted of upwards of 22,000 nutmeg plants. Next to the alluvial deposits, virgin forest lands claim pre-eminence, their surface being clothed with a dark colored carbonized mould, formed by the slow decay of falling leaves and

* From a Paper in the Proceedings of the Agricultural Society established in Sumatra in 1820; cited from the Journ. of the Indian Archipelago and Eastern Asia, v, p. 78, Jan., 1851.

mouldering trunks of trees; and next to these are to be ranked the open plains. Declivities are objectionable from the risk of the precipitation of the mould and manure into the subjacent ravines, by the heavy torrents of rain that occasionally deluge the country. Above all, the plantation must be protected from the southerly and northerly winds by a skirting of lofty trees, and if nature has not already made this provision, no time should be lost in belting the grounds with a double row of the Cassuarina littorea and Cerbera manghas, which are well adapted for this purpose. This precautionary measure will not only secure the planter against eventual loss from the falling off of the blossom and young fruit in heavy gales, but will prevent the up-rooting of the trees, a contingency to which they are liable from the slender hold ther roots have in the soil. If the plantation is extensive, subsidary rows of these trees may be planted at convenient distances. No large trees whatever should be suffered to grow among the spice trees, for these exclude the vivifying rays of the sun and arrest the descent of the salutary night dews, both of which are essential to the quality and quantity of the produce. They further rob the soil of its fecundity, and intermingle their roots with those of the spice trees. It is true that by the protection they afford they prevent frequently the premature bursting of the husk, occasioned by the sudden action of a hot sun upon it when saturated with rain; but the loss sustained in this way is not equal to the damage the spice trees suffer from these intruders. Extensive tracts of land are to be met with in the interior of the country, well adapted for the cultivation of the nutmegs and cloves, and to these undoubted preference is due.

In originating a nutmeg plantation, the first care of the cultivator is to select ripe nuts, and to set them at the distance of a foot apart in a rich soil, merely covering them very lightly with mould. They are to be protected from the heat of the sun, occasionally weeded, and watered in dry weather every other day. The seedlings may be expected to appear in from 30 to 60 days, and when four feet high, the healthiest and most luxuriant, consisting of three or four verticels, are to be removed in the commencement of the rains to the plantation, previously cleared of trees and underwood by burning and grubbing up their roots, and placed in holes dug for their reception, at the distance of eighty feet from each other, screening them from the heat of the sun and violence of the winds. It is a matter of essential importance that the ground be well opened and its cohesion broken, in order to admit of the free expansion of the roots of the tender plants, and that it be intimately mixed with earth and cow manure, in the proportion of two-thirds of the former to one-third of the latter. The plants are to be set in rows as well for the sake of regularity as for the more convenient traversing of the plough, which is

now to be employed in clearing the intermediate spaces of lallang and other noxious grasses, carefully avoiding to trespass on the beds of the trees. They must be watered every other day in sultry weather, manured annually during the rains with four garden baskets full of the above mentioned compost to each tree, and protected from the sun until they attain the age of five years. They will now be sufficiently hardy to bear the sun, and from that age until their fifteenth year, the compost should consist of equal parts of cow dung and burnt earth, and from eight to twelve baskets full will be required for each bearing tree, a lesser proportion being distributed to the males. From the power of habit the trees will, after the fifteenth year, require a more stimulating nutriment; the dung ought not, therefore, to be more than two or three months old, and the mixture should consist of two parts of it to one of burnt earth, of which the suitable proportion will be from twelve to sixteen baskets to each tree biennially. In all cases the prepared compost must be spread out in the sun for three or four days previous to its application, in order to destroy grubs and worms that may have lodged in it, and which might injure the roots of the plants.

In all plantations, whether situated in forest land or in the plains, the necessity of manuring at stated intervals has been found indispensable, and is indeed identified with their prosperity. The proper mode of applying it is in a circular furrow in immediate contact with the extremeties of the fibrous roots, which may be called the absorbents of the plant. Where there is a scarcity of dung, recourse may be had to the dregs remaining after the preparation of the oil from the fruit of the Arachis Hypogæa, which in mixture with burnt earth, is a very stimulating manure; or composts may be formed from the decomposition of leaves or vegetable matter of any description. A very fertilizing and highly animalized liquid nutriment for plants, is obtained by macerating human ordure in water in proper pits for four or five months, and applying the fluid to the radical absorbents of the plants. Seaweed and many other articles may also be resorted to, which will readily occur to the intelligent agriculturist.

During the progressive growth of the plantation, the beds of the trees are to be regularly weeded and the roots kept properly covered with the mould, for these have a constant tendency to seek the surface; the growth of the lateral branches alone is to be encouraged, and all suckers, or dead and unproductive branches, are to be removed by the pruning knife, so as to thin the trees considerably and to admit of the descent of the night dews, which are greatly contributive to their well being, especially during the dry and sultry weather; creepers are to be dislodged, and the lower verticels lopped off, with the view of establishing an unimpeded circulation of air. The conclusion of the great

annual harvest is the fittest time for pruning the trees. After the eradication of the lallang, the growth of innoxious grasses is to be encouraged in the intervals between the trees, which will give the plantation the appearance of a park, and the plough is now to be abandoned.

The nutmeg tree is monœcious as well as diœcious, but no means of discovering the sexes before the period of inflorescence are yet known. The relative proportion of male and female trees to each other is also undefined, and is indeed the result of chance. Setting aside however all pretension to mathematical precision, the number of productive trees may be roundly estimated at two-thirds of the whole cultivation. As the monœcious plants are productive, the number of male trees necessary to be retained will depend entirely on that of the monœcious kind; all above this number, being considered superfluous, should be cut down and other trees planted in their stead. Were I indeed to originate a nutmeg plantation now, I should either attempt to procure grafts on male stocks on such trees as produce the largest and best fruit, by the process of inarching, notwithstanding the speculative hypothesis of the graft partaking of the gradual and progressive decay of the parent tree, leaving a branch or two of the stock for the purpose of establishing a regular polygamy, by which means the plantation would consist of monœcious trees only; or I should place the young plants in the nursery at the distance of four feet from each other, and force them to an early discovery of their sex, by lifting them out of their beds once a year and replacing them in the same spot, so as to check the growth of wood and viviparous branches. The sex might thus be ascertained on an average within the fourth year, and the trees removed to the plantation and systematically arranged, whereas in the usual mode of proceeding it is not ascertainable in general before the seventh year.

Upon an average, the nutmeg tree fruits at the age of seven years, and increases in produce till the fifteenth year, when it is at its greatest productiveness. It is said to continue prolific for seventy or eighty years in the Moluccas, but our experience carries us no farther than twenty-two and a half years, all the trees of which age that have been properly managed, are still in the highest degree of vigor and fecundity; and for this reason no term for planting a succession of trees can as yet be fixed upon. Seven months in general elapse between the appearance of the blossom and ripening of the fruit, and the produce of one bearing tree with another under good cultivation may, in the fifteenth year of the plantation, be calculated at five pounds of nutmegs, and a pound and a quarter of mace. I have observed, however, that some trees produce every year a great quantity of fruit, whilst others constantly give very little. It bears all the year round, but more plentifully in some months than in others. The

great harvest may generally be looked for in the months of September, October, November and December, and a small one in April, May and June. Like other fruit trees on this portion of Sumatra, I have remarked that it yields most abundantly every other year. The fruit having ripened, the outer integument bursts spontaneously, and is gathered by means of a hook attached to a long stick, and the mace being cautiously stripped off and flattened by the hands in single layers, is placed on mats for three or four days in the sun to dry. Some planters cut off the heels and dry the mace in double blades, from an opinion that the insect is apt to breed in or about the heels, and that the double blade gives a better and more substantial appearance to the mace. The former idea is entirely groundless, for if the article be properly cured, kept in tight packages in a dry situation, and exposed to the sun for five or six hours once a fortnight, there need be no apprehension of the insect; and if it is not, it will assuredly be attacked by it whether the heels be cut off or not; again, the insect is much more likely to nestle within the fold of the double blade, and the fancied superiority of appearance has so little weight with the purchaser, as not to counterbalance the risk of probable deterioration and eventual loss. In damp and rainy weather the mace should be dried by the heat of a charcoal fire, carefully conducted so as not to smoke it or blacken its surface.

The nuts liberated from their macy envelope are transported to the drying house, and deposited on the elevated stage of split neebongs, placed at a sufficient distance from each other to admit of the heat from a smouldering fire beneath without suffering even the smallest nuts to pass through. The heat should not exceed 140° of Fahrenheit, for a sudden inordinate degree of heat dries up the kernels of the nuts too rapidly, and its continued application produces fissures in them, or a fermentation is excited in them which increases their volume so greatly as to fill up the whole cavity of the shell, and to prevent them from rattling when put to this criterion of due preparation. The fire is lighted in the night. The smoking house is a brick building of a suitable size, with a terraced roof, and the stage is placed at an elevation of ten feet from the ground, having three divisions in it for the produce of different months. The nuts must be turned every second or third day that they may all partake equally of the heat, and such as have undergone the smoking process for the period of two complete months and rattle freely in the shell, are to be cracked with wooden mallets, the worm-eaten and shriveled ones thrown out, and the good ones rubbed over simply with recently prepared well sifted dry lime. They are now to be regarbled, and finally packed for transportation in tight casks, the insides of which have been smoked, cleaned, and covered with a coating of fresh water and lime. If packed in chests, the seams must be dammered to

prevent the admission of air or water. There is no necessity for sorting them, as previously to their sale they are classed into sizes in the Company's warehouses in London.

The mode generally practised in preparing nutmegs for the market, is to dip them in a mixture of salt water and lime, and to spread them out on mats for four or five days in the shade to dry. I am, however, convinced from much experience that this is a pernicious practice, not only from the quantity of moisture imbibed in this process encouraging the breeding of insects and rendering the nuts liable to early decay, but from the heating quality of the mixture producing fissures and occasioning a great loss in the out turn; whereas by liming them simply in the dry way as I have recommended, the loss ought not to exceed 8 per cent. In May, 1816, I made some experiments on this subject. I cracked a quantity of nutmegs that had been smoke dried for two months, and distributed them into four equal portions. I prepared the nuts of one parcel with a mixture of lime and salt water; those of the second were rubbed over merely with fine well dried shell lime such as the natives use with their betel, although I have no doubt but that recently prepared and well sifted common lime would answer equally well; those of the third parcel were mixed, unlimed, with one-third of their weight of whole black pepper; and those of the fourth, also unlimed, with the same proportion of cloves. They were then put into separate boxes with sliding tops, and numbered 1, 2, 3 and 4, in the order I have mentioned them. At the expiration of the first year they were all sound. After that of the second, I found three worm eaten nuts in No. 1, and two in No. 3, but those in Nos. 2 and 4 remained untouched. The injured nuts were allowed to remain, and after the lapse of the third year, five worm eaten ones were discovered in No. 1, three in No. 3, and two in No. 4, those in No. 2 being in their original state. Four years and four months have now elapsed since the commencement of these experiments, and upon examining the several parcels the other day, the number of decayed nuts has not increased in Nos. 1, 3 and 4, and those in No. 2 are as good as the day they were put into the box. These experiments not only prove the superiority of liming in the dry way, but also the fact that the progress to general decay in a heap of nutmegs, even after the insect has established itself, must be a work of years. In the shell they will keep for a great length of time. I have myself kept them in this state for six years, and when cracked they were found perfectly sound. From the report of the London brokers, however, they will not answer in Europe on account of the heavy allowance for shells, which is one-third of the weight; but the Chinese merchants are in the daily habit of exporting them to Pinang and China, where they are in request. It is stated on the best authority, that unlimed or brown

nutmegs, as the home dealers call them, mixed with cloves as in experiment No. 4, are highly esteemed in England, and even preferred by some to the limed produce; most probably from the greater facility of detecting the flaws in them in their naked state.

Although the clove tree attains great perfection in the red mould of these districts, it is more partial to a less tenacious soil. Its cultivation has been established for many years in the West Indies and at Bourbon, and is of secondary importance only. The mother cloves are planted in rich mould at the distance of twelve inches from each other, screened from the sun and duly watered. They germinate within five weeks, and when four feet high are to be transplanted at intervals of thirty feet, with a small admixture of sand with the red mould so as to reduce its tenacity; and to be cultivated in the same mode as the nutmegs, only that when full grown they require less manure in the proportion of one-third. They yield generally at the age of six years, and at that of twelve are in their highest state of bearing, when the average produce may be estimated at six or seven pounds of marketable fruit each tree during the harvest, which takes place in the rainy months, but with us they have hitherto borne two crops in three years only. The fruit is terminal, and when of a reddish hue is plucked by hand, so that the process of gathering it is tedious. It is then dried for several days on mats in the sun, until it breaks easily between the fingers, and assumes a dark brown color. It loses about 60 per cent. in drying. When past its prime the clove tree has a ragged and uncombed appearance, and I am led to suppose that its existence is limited to twenty years, unless in very superior soil, in which it may drag out a protracted and unprofitable state of being to the period of perhaps twenty-four years. Hence it becomes necessary to plant a succession of seedlings when the old trees have attained eight years of age, and this octennial succession must be steadily kept in view.

With reference to the number of laborers, cattle and ploughs necessary for a plantation of 1000 nutmeg and clove trees, after the ground has been thoroughly cleared of underwood and stumps of trees, I consider that seven Chinese or active Bengalee laborers, fifty head of cattle and two ploughs, would be sufficient for all the purposes of the cultivation, with the exception of collecting the clove harvest, which, being a very tedious process, would require an extra number of hands; and indeed the best plan would be to gather it in by contract.

Art. XXXIII.—*On Coral Reefs and Islands;* by James D. Dana.—Part Fourth.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U.S.N.

Formation of Reefs, and Causes of their Features and Geographical Distribution.

An inquiry into the causes and origin of the features presented by coral reefs and islands, has led us to glance at the nature of coral zoophytes, and at the effects of various agents upon their development. The way has thus been prepared for considering the bearing of these facts, and of other influencing causes, on the growth of the coral plantation as a whole. While, therefore, the preceding pages treat of zoophytes as individual species, the following will relate to those results which proceed from their accumulation, and the causes which have determined the features and geographical distribution of reefs and islands.

1. *Formation of Reefs.*

Very erroneous ideas prevail, respecting the appearance of a bed or area of growing corals. The submerged reef is often thought of as an extended mass of coral, alive uniformly over its upper surface, and, by this living growth, gradually enlarging upward: and such preconceived views, when ascertained to be erroneous by observation, have sometimes led to skepticism with regard to the zoophytic origin of the reef-rock. Nothing is wider from the truth: and this must have been inferred from the descriptions already given. Another glance at the coral plantation should be taken by the reader, before proceeding with the explanations which follow.

Coral plantation and coral field, are more appropriate appellations than coral garden, and convey a juster impression of the surface of a growing reef. Like a spot of wild land, covered in some parts with varied shrubbery, in other parts bearing only occasional tufts of vegetation over barren plains of sand, here a clump of saplings, and there a carpet of variously colored flowers —such is the coral plantation. Numerous kinds of zoophytes grow scattered over the surface, like vegetation upon the land: there are large areas that bear nothing, and others that are thickly overgrown. There is, however, no green sward to the landscape; sand and fragments fill up the bare intervals between the flowering tufts: or where the zoophytes are crowded, there are deep holes among the stony stems and folia.

These observations will prepare the mind for some disappointment in a first view of coral reefs. Nature does not make greenhouses, but distributes widely her beauties, and leaves it for man

to gather into gardens the choicer varieties. Yet there are scenes in the coral landscape, which justify the brightest coloring of the poet: where coral shrubbery and living flowers are mingled in profusion; where Astræa domes appear like the gemmed temples of the coral world, and Madrepore vases, the decorations of the groves; and as the forests and flowers of land have their birds and butterflies, so

"——— Life in rare and beautiful forms
Is sporting amid those bowers of stone,"

for fish of various hues, red, blue, purple, green, and other brilliant shades, keep constant play, appearing and disappearing among the branches.

These fields of growing coral spread over submarine lands, such as the shores of islands and continents, where the depth is not greater than their habits require, just as vegetation extends itself through regions that are congenial. The germ or ovule, which, when first produced, swims free, finds afterwards a point of rock or dead coral to plant itself upon, and thence springs the tree, or some other form of coral growth.

The analogy to vegetation does not stop here. It is well known that the debris of the forest, decaying leaves and stems, and animal remains, add to the soil; and that accumulations of this kind are ceaselessly in progress: that by this means, in the luxuriant swamp, deep beds of peaty earth are formed. So it is in the coral mead. Accumulations of fragments and sand from the coral zoophytes, and of shells and other relics of organic life, are in constant progress; and thus a bed of coral debris is formed and compacted. There is this difference, that a large part of the vegetable material consists of elements which escape as gases on decomposition, whereas coral is itself an enduring rock-material undergoing no change except the mechanical one of comminution. The animal portion is but a mere fraction of the whole zoophyte.

In these few hints, we have the whole theory of reef-making: not a speculative opinion, but a legitimate deduction from a few simple facts, and bearing close analogy to operations on land. The coral debris and shells fill up the intervals between the coral patches, and the cavities among the living tufts, and in this manner produce the reef deposit, which is finally consolidated while still beneath the water.

The coral-zoophyte is especially adapted for such a mode of reef accumulation. Were the nourishment drawn from below, as in most plants, the solidifying coral rock would soon destroy all life: instead of this, the tree is gradually dying below while growing above; and the accumulations cover only the dead portions. Moreover, to prevent accident, where these accumulations do not keep pace with the progress of death, organic incrustations cover the lifeless trunk, and protect it from the dissolving waters.

But on land, there is the decay of the year and that of old age producing vegetable debris; and storms prostrate forests. And are there corresponding effects among the groves of the sea? It has been shown that coral plantations, from which reefs proceed, do not grow in the "calm and still" depths of the ocean. They are to be found amid the very waves, and extend but little below a hundred feet, which is far within the reach of the sea's heavier commotions.* Here is an agent which is not without its effects. The enormous masses of uptorn rock found on many of the islands may give some idea of the force of the lifting wave; and there are examples on record, to be found in various Treatises on Geology, of still more surprising effects.†

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* During the more violent gales, the bottom of the sea is said, by different authors, to be disturbed to a depth of three hundred, three hundred and fifty, or even five hundred feet, and De la Beche remarks, that when the depth is fifteen fathoms, the water is very evidently discolored by the action of the waves on the sand and mud of the bottom. In the *Comptes Rendus*, t. xii, 774, M. Siau mentions that parallel ridges are formed on the bottom, by the motion of the water, which may be readily distinguished at a depth of at least twenty meters. The hollows between such ridges or zones are occupied by the heavier substances of the bottom. Similar zones were distinguished at a depth of one hundred and eighty-eight meters, to the Northwest of the St. Paul's Roads.

† Lyell, vol. ii, p. 38–40. Speaking of the force of waves on coasts, Lyell mentions the transportation of a block of stone, ninety feet from its bed, which was eight feet two inches, by seven feet, and five feet one inch in its dimensions, and another nine feet two inches, by six and a half feet, by four feet, having been "hurried up an acclivity to a distance of one hundred and fifty feet."

In an article on the subject, by Thomas Stevenson, of Edinburgh, published in the Transactions of the Royal Society of Edinburgh, (vol. xvi, 1845,) it is stated, as a deduction from two hundred and sixty-seven experiments, extending over twenty-three successive months, that the average force for Skerryvore, for five of the summer months, during the years 1843, 1844, was six hundred and eleven pounds per square foot; and for six of the winter months of the same year, it was two thousand and eighty-six pounds per square foot, or three times as great as during the summer months. During a westerly gale, at the same place, in March, 1845, a pressure of six thousand and eighty-three pounds was registered by Mr. Stevenson's dynamometer, (the name of the instrument used.) He mentions several remarkable instances of transported blocks. One of gneiss, containing five hundred and four cubic feet, was carried by the waves five feet from the place where it lay, and there became wedged so as no longer to the moved. Of the manner in which it was moved, Mr. Reid (as cited by Mr. Stevenson) says: "The sea, when I saw it striking the stone, would wholly immerse or bury it out of sight, and the run extended up to the grass line above it, making a perpendicular rise of from thirty-nine to forty feet above high water level. On the incoming waves striking the stone, we could see this monstrous mass, of upwards of forty tons weight, lean landwards, and the back-run would uplift it again with a jerk, leaving it with very little water about it, when the next incoming wave made it recline again."

Mr. Stevenson states also that the Bell Rock Lighthouse in the German Ocean, though one hundred and twelve feet in height, is literally buried in foam and spray, to the very top, during ground swells, when there is no wind. On the 20th of November, 1827, the spray rose to the height of one hundred and seventeen feet above the foundations or low water mark; and deducting eleven feet for the tide that day, it leaves one hundred and six feet, which is equivalent to a pressure of *nearly three tons per square foot.*

With such facts, any incredulity respecting the power of waves should be laid aside. Moreover, it may be remarked that the Pacific is a much wider ocean than the Atlantic, with far heavier waves in its ordinary state.

We must, therefore, allow that some effect will be produced upon the coral groves. There will be trees prostrated by gales, as on land, fragments scattered, and fragmentary and sand accumulations commenced. Besides, masses of the heavier corals will be uptorn, and carried along over the coral plantation, which will destroy and grind down everything in their way. So many are the accidents of this kind to which zoophytes appear to be exposed, that we might believe they would often be exterminated, were they not singularly tenacious of life, and ready to sprout anew on any rock where they may find quiet long enough to give themselves again a firm attachment.

But it should be observed, that the sea would have far less effect upon the slender forms characterizing many zoophytes, among which the water finds free passage, than on the massive rock, against whose sides a large volume may drive unbroken. Moreover, much the greater part of the strength of the ocean is exerted near tide level, where it rises in breakers which plunge against the shores. Yet, owing to the many nooks and recesses deep among the corals, the rapidly moving waters, during the heavier swells, must produce whirling eddies of considerable force, tending to uproot or break the coral clumps. These disrupting and transporting effects, will be less and less as we recede from the shores; yet all coral depths must experience them in some degree.

There is another process going on over the coral field, somewhat analogous to vegetable decay, though still very different. Zoophytes have been described as ever dying while living. The dead portions have the surface much smoothed, or deprived of the roughening points which belong to the living coral, and the cells are sometimes half obliterated, or the delicate lamellæ worn away. This may be viewed as one source of fine coral particles; and as the process is constantly going on, it is not altogether unimportant. This material is in a fit condition to enter into solution, and it cannot be doubted that the water receives lime from this source, which is afterwards yielded to the reef.

In the Alcyonia family, which includes semi-fleshy corals, and the Gorgoniæ, the lime is often scattered through the polyps in granules; and the process of death sets these calcareous grains free, which are consequently added to the coral sands. The same process has been supposed to take place in the more common reef corals, the Madrepores and Astræas, and it is possible that this may be to some extent the case. Yet it would seem, from facts observed, that after the secretion has begun within the polyp, the secretion of lime going on takes place *against* the portions already formed and in direct union with them, and not as granules to be afterwards cemented.

The *mud-like* deposits about coral reefs have been attributed to the causes just mentioned, but without due consideration. There is an unfailing and abundant source of this kind of material in the self-triturating sands of the reefs acted upon by the moving waters. On the seaward side of the coral island, and on the shores of the larger lagoons, where the surface rises into waves of much magnitude, the finer portions are carried off, and the coarser sand remains alone to form the beaches. This is a well known fact common on all shores exposed to the waves, coral or not coral, and to this cause the sandy character is attributed. But in the smaller lagoons, where the water is only rippled by the winds, or roughened for short intervals, the trituration is of the gentlest kind possible, and, moreover, the finely pulverized material remains as part of the shores. Thus the fine material of the mud must be constantly forming on all the shores, for the sands are perpetually wearing themselves out; but the mud *accumulates* only in the more quiet waters, and within the lagoons and channels, where it settles, after being washed out from the beaches. This corresponds exactly with the facts; and every lake pool or water of our continents illustrates the same point.*

The coral world, as we thus perceive, is planted like the land with a variety of shrubs and smaller plants, and the elements and natural decay are producing gradual accumulations of material, like those of vegetation. The history of the growing reef has consequently its counterpart among the ordinary occurrences of the land about us.

The progress of the coral formation is like its commencement. The same causes continue with similar results, and the reader might easily supply the details from the facts already presented. The production of debris will necessarily continue to go on: a part will be swept by the waves, across the patch of reef, into

* Mr. Darwin, in discussing the origin of the finer calcareous mud, (op. cit., p. 14,) supposes that it is derived, in part, from Fishes and Holothurias, and other authors have thrown out the same suggestion. He cites as a fact, on the authority of Mr. Liesk, that certain fish browse on the living zoophytes; and from Mr. Allan, of Forres, he learned also that Holothurias subsisted on them. With regard to the facts here stated, I can make no definite assertion. Small fish swarm about the branching clumps, and when disturbed, seek shelter at once among the branches, where they are safe from pursuit: I have often witnessed this fact, and never saw reason to suppose that they clustered about the coral for any other purpose. It is an undoubted fact, however, as stated by Mr. Darwin, that fragments of coral and sand may be found in the stomachs of these animals, though this is not sufficient evidence of their browsing on the coral. The conclusion deduced by him from the facts may be justly doubted. The fish and Holothurias, though numerous, are quite inadequate for the supply; and, moreover, we have, as explained above, an abundant source of the finest coral material without such aid. Motion of particle over particle, will necessarily wear to dust, even though the particles be diamonds; and this incessant grinding action about reefs, accounts satisfactorily for the deposits of coral mud, however great their extent.

the lagoon or channel beyond, while other portions lodge on its surface. But besides the small fragments, larger masses will be thrown on the reefs, by the more violent waves, and commence to raise them above the sea. The *clinker fields* of coral, by this means produced, constitute the first step in the formation of dry land. Afterwards, by farther contributions of the coarse and fine coral material, the islets are completed, and raised as far out of water as the waves can reach—that is, from six to ten feet. The Ocean is thus the architect, while the coral polyps afford the material for the structure: and when all is ready, it sows the land with seed brought from distant shores, covering it with verdure and flowers.

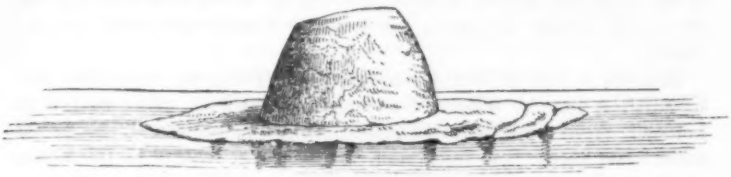
The growth of the reefs and islands around high lands, is the same as here described for the atoll. The reef rock in all cases is mainly a result of accumulations of coral and shell debris. There are reefs where the corals retain the position of growth, as has been described on a former page. But with these, the debris comes in to fill up the intervening spaces or cavities, and make a compact bed for consolidation. There are other parts, especially the outer reef along the line of breakers, which are formed by the gradual growth of layer upon layer of incrusting Nullipores; but in the Pacific, such formations are of small extent.*

Among the peculiarities of coral islands, the *shore platform* appears to be one of the most singular. It will be remembered that it lies but little above low tide level, and is often three hundred feet in width, with a nearly flat surface throughout.

Though apparently so peculiar, the existence of this platform is due to the simple action of the sea, and is a necessary result of this action. Passing to New Holland, from the coral islands of the tropics, we there found the same structure exemplified along the *sandstone* shores of this semi-continent, where it is continued for scores of miles. At the base of the sandstone cliff, in most places one or more hundred feet in height, there is a layer of sandstone rock, lying, like the shore platform of the coral island, near low tide level, and from fifty to one hundred and fifty yards in width. It is continuous with the bottom layer of the cliff: the rocks which once covered it, have been removed by the sea. Its outer edge is the surf-line of the shore. At low tide it is mostly a naked flat of rock, while at high tide it is wholly under water, and the sea reaches the cliff. New Zealand, at the Bay of Islands, afforded us the same fact, again, in an argillaceous sandrock; and there was no stratification in this case to favor the production of a horizontal surface; it was a direct result from the

* Prof. Agassiz has recently observed that deposits of this last kind constitute in many places the reef rock about the Florida Keys.

causes at work. The shore shelf stands about five feet above low water. A small island in this bay is well named the "Old



"THE OLD HAT," BAY OF ISLANDS.

Hat," the platform encircling it, as shown in the above figure, forming a broad brim to a rude conical crown. The water, in these cases, has worn away the cliffs, leaving the basement untouched.

A surging wave, as it comes upon a coast, gradually rears itself on the shallowing shores; finally, the waters at top, through their greater velocity, plunge with violence upon the barrier before it. The force of the ocean's surges is therefore mostly confined to their summit waters, which add weight to superior velocity, and drive violently upon whatever obstacle is presented. The *lower* waters of the surge advance steadily but more slowly, owing to the retarding friction of the bottom; the motion they have is directly forward, and thus they act with little mechanical advantage; moreover, they gradually swell over the shores, and receive, in part, the force of the *upper* waters. The wave, after breaking, sweeps up the shore till it gradually dies away. Degradation from this source is consequently most active where the upper or plunging portion of the breaker strikes.

But, further, we observe that at low tide the sea is comparatively quiet; it is during the influx and efflux that the surges are heaviest. The action commences after the rise, is strongest from half to three-fourths tide, and then diminishes again near high tide. Moreover, the plunging part of the wave is raised considerably above the general level of the water. From these considerations, it is apparent that the line of greatest wave-action, must be above low water level. Let us suppose a tide of three feet, in which the action would probably be strongest when the tide had risen two feet out of the three; and let the height of the advancing surge be four feet:—the wave, at the time of striking, would stand, with its summit, three feet above high tide level; and from this height would plunge obliquely downward against the rock, or any obstacle before it. It is obvious, that under such circumstances, the greatest force would be felt, not far from the line of high tide, or between that line and three feet above it. In regions where the tide is higher than just supposed, as six feet for example, the same height of wave would give

nearly the same height to the line of wave action, as compared with high tide level. Under the influence of heavier waves, such as are common during storms, the line of wave-action would be at a still higher elevation, as may be readily estimated by the reader.

Besides a line of the *greatest* wave-action, we may also distinguish a height where this action is entirely null; and it is evident, from facts already stated, that the point will be found somewhat above low tide level. The lower waters of the surge, instead of causing degradation, are *accumulative* in their ordinary action, when the material exposed to them is movable: they are constantly piling up, while the upper waters are rending and preparing material to be carried off. The height at which these two operations balance one another will be the height, therefore, of the line of no degradation. As the sea at low tide is mostly quiet, and the lower of the surging waters swell on to receive the upper and parry the blow, and moreover, there is next a return current outward,—we should infer that the line would be situated more or less above low tide, according to the height of the tide, and the surges accompanying it. We are not left to conjecture on this point; for the examples presented by the shores of New Holland and New Zealand afford definite facts. Degradation has there taken place sufficient to carry off cliffs of rock, of great extent; yet below a certain level, the sea has had little or no effect. This height, at New Holland, is three feet above ordinary low tide, and at New Zealand, about five feet. With regard to the height varying with the tides, we observe that in the Paumotus, where the water rises but two or three feet, the platform is seldom over four to six inches above low tide, which is proportionally less than at New Holland and New Zealand, where the tide is six and eight feet. From these observations, it appears that the height of *no wave-action*, as regards the degradation of a coast under ordinary seas, is situated near one-fifth tide, in the Paumotus, and above half tide at New Zealand, showing a great difference between the effect of the comparatively quiet surges of the middle Pacific, and the more violent of New Zealand. Within the Bay of Islands, where the sea has not its full force, the platform, as around the "Old Hat," is but little above low water level. The exact relation of the height of the platform to the height and force of the tides remains to be determined more accurately by observation. While, therefore, the height of the shore platform depends on the tides, and the usual strength of the waves, the breadth of it will be determined by the same causes in connection with the nature of the rock-material.*

* On basaltic shores it is not usual to find a shore platform, as the rock scarcely undergoes any degradation, except from the most violent seas; such coasts are con-

It is apparent that one single principle meets all the various cases. The rocky platform of some sea-shores, the low tide sand-spit on others, and the coral-reef platform of others, require but one explanation. The material of the coral platform is piled up by the advancing surges, and cemented through the infiltrating waters. These surges, advancing towards the edge of the shelf, swell over it before breaking, and thus throw a protection about the exposed rocks; and as the tide rises, this protection is complete. They move on, sweeping over the shelf, but only clear it of sand and fragments, which they bear to the beach.

The isolated blocks in the Paumotus which stand on the platform, attached to it below, are generally most worn one or two feet above high tide level, a fact which corresponds with the statement in a preceding paragraph with regard to the height of the greatest wave-action.

In addition to this ordinary wave-action, there are also more violent effects from storms; and these are observed alike on the Australian shores referred to, and on those of coral islands. The waters, moving through greater depths, and driving on with increased velocity up the shallowing shores among cavities or under shelving layers, break and lift the rocks of the edge of the platform, and throw them on the reef. From the observations of Mr. Stevenson, cited in a note to a preceding page, it appears that the force of the waves during the summer and winter months differs at Skerryvore more than 1200 pounds to the square foot, —in the former it averaging but 636 pounds, and in the latter 2086 pounds, while in storms it was at times equivalent to 6083 pounds. The seasons are not as unlike in the tropical part of the Pacific. Still there must be a marked difference between the ordinary seas and those during stormy weather. We have therefore no difficulty in comprehending how the ordinary wave-action should build up and keep entire the shore platform, while the more agitated seas may tear up parts of the structure formed, and bear them on to the higher parts of the island. Still more violent in action are the great earthquake-waves, which move through the very depths of the ocean.

These principles offer an explanation also of the general fact that the windward reef is the highest. The ordinary seas, both on the leeward and windward sides, are sufficient for producing coral debris and building up the reef, and in this work the two sides may go on with almost equal rate of progress: consequently we may often find no very great difference in the *width* of the

sequently often covered with large fragments of the basaltic rocks. But on sandstone shores, this gradual action keeps the platform of nearly uniform breadth. Moreover, any uptorn masses thrown upon it, are soon destroyed by the same action, and carried off; and thus the platform is kept nearly clean of debris, even to the base of the cliff.

leeward and windward reefs, especially as the wind for some parts of the year has a course opposite to its usual direction. But seldom, except on the side to windward, is a sufficient force brought to bear upon the edge of the platform, to detach and uplift the larger coral blocks. The distance to which the waves may roll on without becoming too much weakened for the transportation of uptorn blocks, will determine the outline of the forming land. With proper data as to the force of the waves, the tides, and the soundings around, the extent of the shore platform might be made a subject of calculation.

The effect of a windward reef in diminishing the force of the sea is sometimes shown in the influence of one island on another. A striking instance of this is presented by the northernmost of the Tarawan Islands. All the islands of this group are well wooded to windward—the side fronting east, between north and south. But the north side of Tari-tari is nothing but a bare reef, through a distance of twenty miles, although the southeast reef is a continuous line of verdure. The small island of Makin, just north of Tari-tari, is the breakwater which has protected the reef referred to from the heavier seas.

Coral island accumulations have one advantage over all other shore deposits, owing to the ready agglutination of calcareous grains, as explained on a following page. It has been stated that coral sandrocks are forming along the beaches, while the reef-rock is consolidating in the water. A defence of rock against encroachment is thus produced, and is in continual progress. Moreover, the structure built amid the waves will necessarily have the form and condition best fitted for withstanding their action. The little islet of an atoll is therefore more enduring than hills of harder basaltic rocks. Reefs of zoophytic growth but "mock the leaping billows," while other lands of the same height gradually yield to the assaults of the ocean. There are cases, however, of wear from the sea, owing to some change of condition in the island, or in the currents about it, in consequence of which, parts once built up are again carried off. Moreover, those devastating seas which overleap the whole land may occasion unusual degradation from some parts. Yet these islets have within themselves the source of their own repair, and are secure from all serious injury.

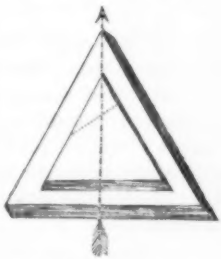
The lagoons in coral islands are constantly receiving more or less debris from the reefs; and patches of growing coral within also tend to fill them up. But the effect is slow in its progress, and none but islands of small size, as before stated, show any approximation to an obliteration of the lagoon.

Art. XXXIV.—*Optical and Blowpipe Examination of the supposed Chlorite of Chester County, Pa.;* by W. P. Blake.

Read before the American Association for the Advancement of Science, at Albany, August, 1851.

In September, 1850, Prof. B. Silliman, Jr., handed me a specimen of a beautiful green foliated mineral for optical examination; it was unexpectedly found to be biaxial; but as the locality of the specimen was not known, no further examination than the measurement of the angles was made at that time. In May, of this year, I received from Prof. J. D. Dana specimens of the hitherto supposed chlorite, of Chester Co., Pa., which I examined by polarized light, and obtained results so similar to those obtained with the specimen first referred to, as to leave no doubt of its being from the same locality.*

The mineral occurs three miles south of West Chester, in serpentine associated with magnesite, and is found in plates of irregular outline, sometimes three inches broad, and in triangular plates and tabular masses, one of which is represented in the annexed figure. These plates are equilateral triangles; and they much resemble the triangular cleavage specimens of the micas from Greenwood furnace and Monroe, N. Y. The cleavage is perfect, parallel with the broad faces of these crystals, but is not so perfect as in mica, and the laminæ are more brittle. The laminæ are flexible and elastic, but less elastic than mica. Color, beautiful emerald green. Hardness of cleavage surface, 2 to 2·25, scale of Mohs. Specific gravity 2·714, which is perhaps too low, as no specimen could be obtained perfectly free from air.



Optically it is biaxial, with a high angle, and the following are the results obtained:

Specimen *a*, examined in September, plate one decimetre long and six centimetres broad, with an irregular outline.

Specimen *b*, a triangular plate measuring one and one-fourth inches along each side, examined in May.

Apparent angle between the optic axes in *a*, 84°·30′ mean of nine measurements.

Apparent angle in *b*, 85°·59′ mean of five measurements.

The plane of the axes is perpendicular to the cleavage surface and at right angles with the base of the triangle, as indicated by the arrow in the figure. I was also able to obtain evidences of

* Prof. Dana received his specimen from Thos. F. Seal, of Philadelphia.

optic axes in the angle of the plate opposite to the base, and found them to have an equal inclination with *b*; and the plane of these axes was found to form an angle of about 60° with the plane of the others, or to be at right angles with one of the sides of the triangle, (which is as near the angle as could be determined by marking the direction upon the plate and subsequent measurement by goniometer and protractor,) this peculiar relation of two systems of optic axes, had been noticed in *a* also, and there is probably a line of composition in most of the crystals from the locality. The position of this line is represented by the shorter dotted line in the figure.

Another interesting peculiarity is, that the optic axes are *not equally inclined to the cleavage surface*, or to a line perpendicular to it, (the "normal" of Biot.) The inclinations were measured, but as the instrument had not been adapted to this mode of measurement, the angles given can be regarded only as approximations, and are here given merely to show the existing inequality of the inclinations.

Spec. *a* gave the angles . . . 50° and 34°.
" *b* " " " . . . 58°·13′ and 27°·40′.

The greater angle being on the side of the "normal" adjoining the base of the plate or triangle.

From these results the mineral must be referred to one of the systems of crystallization having the three axes unequal,—and it cannot therefore be classed with the species chlorite or ripidolite, which according to authors is rhombohedral or hexagonal. The Ala chlorite was examined optically by Biot and reported to be *uniaxial.*

It is here interesting to observe that we have this undoubtedly *clinometric* mineral with such a peculiarly high angle between the optic axes, occurring in triangular plates and masses so much resembling the micas from Monroe, N. Y., whose biaxial character is so difficult of determination, and which by reason of this form have been referred by some eminent crystallographers to the rhombohedral system. The form in both cases may be considered as resulting from an acute oblique rhombic prism by the replacement of the acute solid angles.*

Examined with the blowpipe the mineral gives the following reactions.

B.B. in the forceps, contracts and becomes opaque and white, with traces of fusion on the edges. Alone, on charcoal, same as with forceps. In an open tube, gives off water, and a white ring is formed near the assay when strongly heated. With borax in the oxydating flame, dissolves readily with much ebullition; the glass while hot, red and brownish, but becomes

* Dana's Mineralogy, 1st edition, p. 264, and Am. Jour Sci., 2d Ser., xii, p. 8.

green when cold; in the reducing flame, while hot, color not so deep as in the oxydating flame, and passes through the shades of olive green while cooling, to beautiful emerald green when cold. With phosphate of soda and ammonia in the oxydating flame, dissolves slowly, leaving a skeleton of the fragments; glass red and yellowish while hot, fine green when cold. When much of the assay is added, the glass becomes opalescent to opaque when cooling; in the reducing flame, skeleton disappears, bead brown while hot, opalescent and green while cold. With carbonate of soda on platina foil, no reaction for manganese.

The constituents of the mineral so far as indicated by the above reactions are, Ĥ, S̈i, C̈r, F̈e. Analyses are now in progress at the Yale Analytical Laboratory.

In addition to the optical character, the mineral is shown to differ from chlorite in hardness and elasticity, and by the presence of chromium.

I propose for the species the name *Clinochlore*, in allusion to the great obliquity between the optic axes, and its green color resembling that of chlorite.

A similar mineral from Unionville occurring in triangular and hexagonal forms, I have found to be biaxial and probably like the above; but I have not yet succeeded in obtaining any measurements.

ART. XXXV.—*Notes of a Discussion of Tidal Observations made in Connection with the Coast Survey, at Cat Island, in the Gulf of Mexico;* by Prof. A. D. BACHE, Superintendent,* with five plates.

IN executing the hydrography of the entrance of Mobile Bay and of Mississippi Sound, connected tidal observations were made under the immediate direction of Lieut. Comd'g. C. P. Patterson, U. S. N., Assistant in the Coast Survey.

The observations at Cat Island, at the entrance to Lake Borgne, Louisiana, and at Fort Morgan, at the entrance to Mobile Bay, have undergone more than one discussion, the peculiarities of the tides giving great interest to the observations.

The results, as obtained from a year's hourly observations day and night at Cat Island, will be given as far as obtained, the steps taken for further progress stated, and the information which has been obtained from other sources bearing upon this most interesting problem of the tides in the Gulf of Mexico, will be briefly touched upon.

* From the Proceedings of the American Association for the Advancement of Science, 4th meeting at New Haven, 1850, p. 281. Revised by the author for this Journal.

I hope, in the progress of the Survey along this part of our coast, to develop the subject of these tides, full of importance to the navigator, and of interest to the man of science. These tides, with special exceptions, ebb and flow but once in twenty-four hours.

The tide gauge was of the kind known as the box gauge, with a float and staff, graduated into feet and decimals of a foot. It was placed in the harbor of Cat Island, near the light-house, at the extremity of a temporary wharf.

The harbor, as the Coast Survey chart which I now present to the meeting shows, turns its widest and deepest opening to the East.

Apparent time was given by a mark, and the observations were made at mean solar time by applying the equation. The time was of less consequence than ordinary in these observations, from the small rise and fall of the tide, which prevented small differences of time from being noticeable by differences of rise and fall. Slight inequalities, caused chiefly by wind, were also found to affect the observations so materially that it was not deemed advisable to observe oftener than once the hour; and after attempting to determine the epoch of high and low water by more frequent observations, it was decided that errors would probably be introduced by aiming at a degree of precision which the phenomena themselves did not present.

The observations were made day and night, hourly, for a year, with exceedingly rare omissions, and, as the discussion has shown, with a degree of faithfulness which merits very great praise. The observers were Messrs. Gustavus Wurdeman and R. T. Bassett, attached to the Coast Survey.

The general opinion of nautical men on the subject of these tides is, that they mainly depend upon the action of the wind; and the very regular effect which may be shown to result from a discussion of the tides in reference to the local action by the wind, lends plausibility to this generalization, which nevertheless is unfounded.

The causes are of a much more general character, and such as usually influence the tides, so modified as to be difficult to bring out; phenomena which are only accessory in the ordinary discussions assuming here the chief and overruling part.

The regular tabulation of the observations was made by Lieutenant Comd'g. C. P. Patterson, who did not fail to perceive that the ordinary methods of discussion of the tides were inapplicable. His removal from the Survey on other professional service has devolved upon me the labor of discussing the results.

Their importance, interest, and novelty, so far as our coast and their striking peculiarities are concerned, have justified me in giving much time to the discussion, which has been carried on

under my immediate direction, by Mr. G. W. Dean, Sub-Assistant in the Coast Survey, and by Messrs. R. M. Bache, A. S. Wadsworth, Jr., and W. M. Johnson.

I am indebted for the diagrams necessary to illustrate the conclusions already arrived at, to Messrs. Bache, Johnson, and Keyser.

I present a part only of the labors of these gentlemen. The whole of the hourly observations for the year have been thrown in the form of curves, and numerous tables for examining and verifying the different hypotheses have been made by them. Though the subject was reached inductively, I do not propose to present it strictly in that form.

The work even now is far from being complete; indeed we have rather reached the true method of discussion, than have completed the discussion; and we may yet have to modify our hypothesis, though I think not materially. I present it to the Association as a work in *progress*. When the investigation for this station is made complete, the application of the methods to the other stations on the Gulf of Mexico will be in a degree mechanical.

It is curious that one among the earliest complete series of tidal observations on record, is of tides ebbing and flowing but once in twenty-four hours. The observations were made by Mr. Francis Davenport, at Batsha, of the tides on the bar of Tonquin, and communicated to Dr. Halley, who gave them, with a diagram connecting the phenomena with the moon's motion in the ecliptic, in the thirteenth volume of the Philosophical Transactions for the year 1683. Newton explained these tides by his lunar theory, but in a way, as appears to me, to leave it doubtful whether he supposed the interference of two ordinary or six hour tides to produce the phenomena. These tides have been referred to since by almost every writer of note, who has given a general theory of the tides.

The subject of the diurnal inequality of the tides has been so completely and ingeniously discussed by Mr. Whewell, Master of Trinity, that it may be said emphatically to be his own. He first pointed out the empirical law of variation of this inequality. The first distinct attempt to trace the cause of apparent ebb and flow once in twenty-four hours to the influence of the diurnal irregularity, is also, so far as I know, his. In discussing (Phil. Trans. for 1837, Part I,) the tides at Singapore, where the diurnal inequality is very large, he was led to the conclusion, if carried a little further, "at a certain stage of it the alternate tides would vanish." To this effect he attributed the "single day tides of King George's Sound, on the coast of New Holland, as observed by Captain Fitz Roy," and gives the curves for a week's observations on the diagram accompanying his papers. The progress of the diurnal inequality wave along the coast of Europe forms

an interesting part of Mr. Whewell's labors, the conclusions of which are given in the same volume of the Phil. Trans.

In all these cases, however, there are two tides in the course of the day, so as to bring out the diurnal inequality by the comparison of the consecutive high or low water. The subject is followed up in the eleventh series of tidal researches by Mr. Whewell, and in the appendix, in which the diagrams of the tides of Petropaulofsk, in the Bay of Avatcha, Kamtschatka, approaching very nearly, at certain parts of the lunar month, to the order of single day tides, is given, to prove that the diurnal inequality may be so large "as to lead to the appearance of only one tide in twenty-four (lunar) hours." The equations of the diurnal and semi-diurnal tide waves are given in this paper, and the wave produced by certain cases of their interference is discussed. (Phil. Trans. for 1840.)

I do not pretend to give such notice of these important papers as would be necessary in a formal communication. Unquestionably the observations now under examination would have furnished to Mr. Whewell only the means of trying ideas and consequences flowing from those which have been already discussed by him, yet the forms of discussion are original, and perhaps new, and the conclusions present so much of novelty that they remain to be fully put to the test by more elaborate discussion, and by bringing the results at other places to bear upon the same question. I am forced by the necessity for brevity to omit a reference to the learned, ingenious, and elaborate paper of Mr. Airy, in the Phil. Trans. for 1848.

The small rise and fall of the tides, amounting on the average to but one foot, would seem to make it difficult to obtain the law of the phenomena, even with the aid of the most careful and truthful observations, the class to which those under discussion have proved to belong. In regard both to time and height, we may expect to be baffled by small irregularities, requiring long continuance of observations and comparisons of means, to get rid of. Thus far, few cases have occurred which do not exhibit more striking coincidences than differences.

1. To show the time of high or low water in such a way that the discussion might be readily generalized, the diagrams, of which a specimen is before the Association, were made (Pl. 3, or No. 1); the hours of the day are the ordinates, and the days of the month the abscissa. The signs H and L show in their proper place the hour of occurrence of high and low water for each day. The time of the moon's superior transit is marked, and the periods of greatest declination, and of crossing the equator. The result is easily generalized, that there is ordinarily but one high and one low water at Cat Island in twenty-four (lunar) hours, and that when there are two tides they occur about the time of the moon's

crossing the equator, and are usually most regular and strongly marked when in syzigies, with declination nearly zero. Following one set of high and low waters, it will be found that they occur later and later as the lunar day gains on the solar, with very remarkable differences, of which the explanation will be given, towards the period of small declinations. The interval from high to low water is generally less by some hours than that from low to high. That as the moon approaches the equator, there are a few days of singular double tides, or of single tides, in which the times from low to high water are very much increased. That when the declination changes its name, a high tide takes nearly the place of a low in time, and *vice versa*, with an interval of irregularity, or, in other words, the tides are displaced by nearly twelve hours.

2. There is, as Mr. Whewell has remarked, no proper establishment to be derived from such tides; yet we may obtain a desirable datum by throwing the results into the form of tables, in which the luni-tidal intervals are arranged according to the days from the zero of declination and the corresponding superior and inferior transits, and for north and south declinations. This will be made more clear by subsequent explanation. These afford a test of the theory of these tides, by showing the displacement of the ordinate of high and low water, and might be used for the inverse purpose of forming prediction tables. Such tables of luni-tidal intervals for three months I now submit. They show considerable steadiness and similarity of intervals towards the maximum of declinations, and great variations near the zero, and greater discrepancies than is usual in ordinary tides. These are from a series of tables computed by Mr. R. M. Bache for the year, and containing the times of high and low water, deduced from the daily curves, the readings of the gauge, the rise and fall of the tides, the times of the moon's superior and inferior transit, and the moon's declination.

The intervals serve to show that the high water belongs alternately to the superior and inferior transits of the moon, according as the moon's declination is north or south, with a few cases only which admit of doubt. Two sets of luni-tidal intervals were computed (see tables) for three months, to ascertain the proper epoch of reduction (or age of the tide). In one case the intervals were referred to the superior transit of one day before, and in the other to the superior transit of two days before. The square of the discrepancy of the mean in the latter case was greater than in the former. An establishment deduced from these numbers for high water without correction would have a probable error, as tried by discrepancy from the mean, of nearly eighty-four minutes. I have little doubt of being able to reduce this error, by computation, much within the limits of observa-

tion, so as to give useful prediction tables. The foregoing results point distinctly to a ruling cause depending upon the moon's declination.

3. The hourly observations for the year were thrown into the form of curves, the abscissas representing the hours and the ordinates the heights. Of these I present, as characteristic, the months of January and March (Pl. 4, 5, or Nos. 2, 3). In January the tides are single throughout the month, the rise and fall diminishing towards the zero of declination; and in March two periods of marked double tides occur. The times of new and full moon coincide nearly with the zero of declination of March; in January the syzigies occur at times of greatest declination. A series of diagrams, prepared for periods of declination zero, shows irregularities or double tides near these times. Before disappearing, the tide which is lost appears rather as an irregularity than as a real tide, puzzling to the observer and a severe test of his faithfulness. A similar set of diagrams for the periods of greatest declination show uniformly single tides and the greatest comparative rise and fall at the same periods, whether coinciding with syzigies or with first and last quarters. In computing the heights of spring and neap tides by the common methods, four months gave zero or negative differences.

To discuss the epochs of the phenomenon, as compared with greatest and least declinations, I prepared two sets of tables, which require revision.

They show sometimes an actual coincidence in the epoch of least tides and zero of declination, sometimes a precedence and sometimes a subsequence, which, when not caused by irregularity of winds, I believe will find a satisfactory explanation; at a mean, there was little advantage in the discussion found from displacing the epoch. The average rise and fall for the second day before the greatest declination was 1·68 feet, for the day next preceding the greatest declination 1·78, for the day of greatest declination 1·81, for the next day 1·86, and for the next 1·77. Tracing a curve from these would give the epoch of greatest rise and fall about 0·75 days after the greatest declination. The average rise and fall on the corresponding days, in reference to declination zero, were 0·96 feet, 0·75, 0·60, (dec. zero,) 0·63, 0·73, the curve giving the epoch about one-sixth of a day after the zero of declination. The numbers, as stated, require revision; and there are causes for an apparent displacement, which require further examination.

4. This general examination tends to point to the diurnal irregularity, as Mr. Whewell has stated, as the cause of the occurrence of these single day-tides; a view which is confirmed by such examinations as I have been able to make of the hourly tidal observations at Fort Morgan, at the entrance of Mobile Bay.

The interference in this case would be between the diurnal tide-wave, which represents the diurnal inequality and the ordinary semi-diurnal wave, whether this wave has a regular progress along the coast independently of the semi-diurnal wave, as was at first supposed by Mr. Whewell, or whether its phenomena are local, as he has since been led from his investigations to believe. If the observed wave is produced by its interference with a semi-diurnal wave, we can only study the phenomena to advantage after the observed wave has been separated into its components.

5. As a first approximation, I assumed the two waves to be governed by the law of sines, and then determined the curve which would result from the superposition of two such waves, having the same or different origins. The mean of the regular double tides about the zero of declination would present a first approximate value of the rise and fall of the semi-diurnal tides, and the mean of double and single tides at the maximum of declination would, especially when near the quadratures, give a first approximation to the height of the diurnal tide. The comparisons with the forms of curves already traced, addressing the eye, are easily made.

I present herewith diagrams (Pl. 6, or No. 4) for the case, in which the maximum of the diurnal tide coincides with that of the semi-diurnal, is three hours in advance, (or coincides with mean water falling,) six hours, (or coincides with low water,) and nine hours, (or coincides with the second mean, or mean water rising,) using the approximate quantities referred to above for the greatest height of two component curves. It requires little examination to see that neither of the first three forms represents the case, and that the fourth does so remarkably, even in what appear to be small irregularities in the daily curves. This will be seen in the results for October, of which a diagram on a large scale is presented, giving the tidal curves near the zero, and thence up to the maximum of declination for the first half of the month. In the single day tides there was the same slow rise compared with fall, sharp rise and fall near high and low water, with the tendency to a stand during the rise; the same excess in the interval of time from low to high water, over that from high to low water. This hypothesis as to the position of the two waves may perhaps be slightly improved by further discussion. It is obvious from the equation of the curve (which I have already referred to as given by Mr. Whewell), that the form and position of remarkable points will vary with the constants in the component curves, as well as with the position of the origin of each in reference to that of the other.

To carry out the representation graphically, I have drawn the curves for four values of the constants of the diurnal and semi-

diurnal, formed from the observations with the same displacement of nine hours in the time of high water of the diurnal curve, and corresponding to the epochs of the maximum declination, two, four, and six days before or after the maximum. These show the general features of the curve sufficiently, and the variations in the times and heights, the passage from single to double tides, and the reverse; and the coincidence with observations is such as to warrant a close numerical discussion.

6. The equation of the curve shows how the time of high and low water depends on the constants in the diurnal and semi-diurnal curve.

The equivalent of the equation given by Mr. Whewell is—

$$C \cdot \cos 2t + D \cos (t - E) - y = 0,$$

in which t is the time in hours from the place of the maximum ordinate of the semi-diurnal curve as an origin; C is the constant of that curve of sines; E is the distance of the maximum ordinate of the diurnal curve for the former, and D the constant for the curve of sines; y is the ordinate of the complex curve.

By an easy transformation, this takes the form,

$$2C \cdot \cos^2 t + D \cos t \cdot \cos E + D \cdot \sin t \cdot \sin E - C = y.$$

For E = 9 hrs. $\quad \text{Cos } E = -\sin E = -\sqrt{\tfrac{1}{2}},$

and $\quad y = 2C \cos^2 t + D \sin E (\sin t - \cos t) - C.$

The differential co-efficient of which for the case of the maximum or minimum is

$$\frac{dy}{dt} = -4C \cos t \cdot \sin t + D \sin E (\sin t + \cos t) = 0$$

$$\frac{1}{\sin t} + \frac{1}{\cos t} = \frac{4C}{D \sin E} = \frac{4C}{D\sqrt{\tfrac{1}{2}}},$$

or, since the second term is negative when $t > 6$ hours,

$$\text{cosec} \cdot t - \sec t = \frac{4C}{D\sqrt{\tfrac{1}{2}}}.$$

Applying this to the four cases shown in the diagrams

		hrs.	min.
E = 9 hours, C = 0·175,	D = 0·700 we find maximum at	10	25·4
	= 0·615	10	33·3
	= 0·400	10	51·1
	= 0·157	11	56·8

and for the intervals between high and low water in lunar hours,

h. m. h. m. h. m. h. m.
9 09·2, 8 53·4, 8 17·8, and 6 06·4.

We might apply this mode to test the hypothesis, using for the values of C, the half difference of the ordinates of six and twelve hours from the mean, and of eighteen and twenty-four hours with the signs changed, and for D, the average of the or-

dinates of six and eighteen hours from the first mean. The means present the best criterion because not displaced in this combination as the equation shows. This mode of proceeding, however, throws the test too much on the weak part of the results, the times of occurrence of high and low water, or of mean water, and does not take in all the points of the curve, and I have therefore preferred a different form of discussion.

7. Placing the maximum of the semi-diurnal curve at 0 hours, in the hypothesis that the high water of the diurnal curve is nine hours in advance of that of the semi-diurnal curve, the two curves cross the line of mean water at three hours, the diurnal curve rising and the semi-diurnal falling; at six hours, the semi-diurnal curve has reached its maximum, and rises again at nine hours to its intersection with the mean water line, at which time the diurnal curve has reached its maximum; the semi-diurnal curve attains its greatest rise at twelve hours, and the mean level at fifteen; the diurnal curve also descending to the same point at that time.

Within these two intervals from mean level to mean level, the combinations of the ordinates forming the actual tidal curve are exhausted; the part of the curve below the mean level being symmetrical with that above. From three to nine hours, the ordinates of the semi-diurnal curve are subtractive; from nine to fifteen hours, additive. The mean is the average between high and low water. The tides of each day will give the forms of the component curves, beginning with the mean, and ending with it, considering as symmetrical the parts above and below the axis of X.

In tabulating, the branch above the axis should be referred to the mean of the preceding and succeeding low water $\left\{\frac{1+1'}{4}+\frac{h}{2}\right\}$ and of the high water which it includes, and that below to the mean of the two high, and of one low water. From three to nine hours, the difference of the ordinates giving the actual curve, and from fifteen to nine in the reverse order the sum of the same ordinates, half the sum of the two series of ordinates gives the value of the ordinates of the diurnal curve, and half the difference, the ordinates of the semi-diurnal curve. The same being repeated with the second branch of the curve, the average will give two results for each day's observation.

The case given in the table on the board, for March 5, will serve to illustrate the simple nature of this method of proceeding.

The mean ordinate for the first and second branches of the curve having been obtained, and the hourly observation which coincides most nearly with it having been found before and after high water, the hourly observations are arranged from it forwards

for seven hours (m) and backwards for seven (n). The same is done for low water, (m′ and n′.) The half sums and half differences are taken in each case, and then the means. The computation of the diurnal curve is made in the upper part of the table, and that of the semi-diurnal curve in the lower part. The number representing the mean level is eliminated by the mode of taking the means in each table, and the ordinates below the axis are treated as if having the same sign as those above. The semi-diurnal curve is turned over on its maximum ordinate, and the mean value of a single branch of it found. Then each curve is reduced to zero, in the mean level of the period. The last two columns of the upper and lower part of the table contain respectively the curves of sines corresponding to the diurnal and semi-diurnal curves.

In the case shown in the first diagram, the ordinates of the semi-diurnal curve from mean water to high water, and corresponding nearly to a minimum of declination, and new moon, are 0·00 feet, + 0·02, + 0·03, + 0·05, + 0·04, − 0·02, + 0·02. The moon's declination during the period being about from 2° 54′ S., to 1° 45′ S.; this curve obviously contains a residual of the semi-diurnal curve, not taken out, but supposing it to be deduced from a just mean, the corresponding ordinates of a semi-diurnal curve, calculated with 0·04 feet as the maximum would be 0·00 feet, 0·01, 0·02, 0·03, 0·03, 0·04, 0·04, differing at the most, 0·06 of a foot, or about three-quarters of an inch, and in a single instance, the sum of all the six differences being 03 feet, and the average ·004.

The ordinates of the semi-diurnal curve are 0·00 feet, 0·14, 0·28, 0·32. The curve of sines computed with the greatest ordinate has in this case for its corresponding ordinates 0·00 feet, 0·16, 0·28, 0·32, differing but ·02 feet at the greatest.

At the next period of declination nearly zero, and full moon in the month of March, the ordinates of the diurnal curve deduced are 0·00 feet, 0·05, 0·06, 0·06, 0·08, 0·06, 0·09, and the corresponding computed ordinates 0·00 feet, 0·02, 0·04, 0·06, 0·07, 0·09, 0·09, differing at the greatest 0·03 feet, and on the average, 0·004 feet, the observed ordinate being this time in excess as it was before in defect. The ordinates of the semi-diurnal curve are 0·00 feet, 0·12, 0·22, 0·26, and the computed ones, 0·00 feet, 0·13, 0·24, 0·26, the greatest difference being 0·02 feet, and the average 0·007 feet in excess, as was the former.

For March 12, corresponding to the maximum of the diurnal curves, and to neap tides (one day after last quarter), the ordinates of the hourly diurnal curve from mean to high water are 0·00 feet, 0·21, 0·36, 0·51, 0·63, 0·69, 0·71, the corresponding ordinates of the curve of sines being 0·00 feet, 0·18, 0·35, 0·63, 0·69, 0·71, in which the greatest difference is 0·03 feet, and the

mean +0·007 in the curve computed from observation. The ordinates of the semi-diurnal curve are each zero. Two days afterwards, viz. March 13, gives for the diurnal curve, 0·00 feet, 0·18, 0·34, 0·47, 0 61, 0 68, 0·74, corresponding to which is the curve of sines 0·00 feet, 0·18, 0·37, 0·51, 0·63, 0·72, 0·74, in which the greatest difference is 0·04 feet, and the mean −0·02 feet, the curve of observation having the least ordinates. The semi-diurnal curve is 0·00 feet, 0·00, 0·03, 0·02.

The average of three months, taken by weeks, gives for the mean curve and curve of sines the following table:—

Hours.	Diurnal Curve.			Semi-Diurnal Curve.	
	From Observat'n.	Of Sines.	Diff.	From Observation.	Of Sines.
	Feet.	Feet.		Feet.	
0	0·00	0·00		0·00	0·00
1	0·17	0·15	0·02	0·04	0·04
2	0·32	0·30	0·02	0·07	0·07
3	0·43	0·42	0·01	0·08	0·08
4	0·52	0·52	0·00		
5	0·56	0·58	—0·02		
6	0·58	0·60	—0·02		
			Sum 0·01		

These results are shown by a curve in the diagram herewith presented (Pl. 7, or No. 5,) on the full scale,* the greatest difference between the curve from the observation and the curve of sines being less than a quarter of an inch in the mean deduced from three months observations. Whether this will disappear in the mean of more observations or whether a modification of the hypothesis of displacement of nine hours must be made to meet it, further computations now in progress will show.

8. When this analysis has been made as complete as possible, and applied to the year's observations, it will remain to take up the two series into which we have divided the observations, and to discuss them numerically in detail, as we have heretofore done, generally, in regard to the known laws of the diurnal irregularity, and of the ordinary tides.

Each determination gives a corresponding value of the maximum, or of the ordinate of high water, and in the case of the mean of the curves for January, February, and March, these maxima are 0·66 feet, 0·65, 0·60, 0·60, 0·58, 0·58. Mean 0·61 feet, differing ·03 of a foot, from the maximum found directly from the observations, and if the discrepancies are accidental, giving a mean probable error by the variations from the average of 0·02 feet (one-quarter of an inch) of any one of the determinations, and for the mean, 0·01 feet nearly.

9. By the kindness of Col. Abert, of the Topographical Engineers, of Major Bache, of the same corps, and of Lieut. Maury, Superintendent of the National Observatory, I have been put in

* Reduced in the plate.

possession of tidal registers which have been kept during the progress of the local surveys made of harbors on the coast of the Gulf of Mexico. The tidal observations of Major Bache, U. S. Topographical Engineers, at Key West and the Tortugas, are the most complete of this series, and show, as a general phenomenon, the prevalence of the semi-diurnal wave at that point. I have not yet had the opportunity to examine fully these results, which are however under discussion.

ART. XXXVI.—*The Silurian Basin of Middle Tennessee, with notices of the Strata surrounding it;* by JAMES M. SAFFORD, A.M., Prof. of Chemistry and Geology, Cumberland Univ., Lebanon, Tenn., with a plate.

1. THE rocks of Middle Tennessee, west of the Cumberland Mountains, belong, for the most part, to strata below the Pentremital carboniferous limestones.

2. They may be divided into *five* natural but unequal groups, (see table, § 7.)

The *First* and *Second*, commencing with the lowest, comprise the "Blue limestones" of western geologists.

The *Third* includes the gray limestone of the Harpeth and Tennessee rivers.

The *Fourth*, the well known "Black slate."

The *Fifth* and uppermost, the "siliceous stratum" of Dr. Troost—a heavy group, often including limestone, but well marked everywhere by its siliceous character.

3. The strata of these groups, originally, formed a slightly elevated dome, the denuded summit of which is in Rutherford county. Here the lowest of the rocks under review are visible. From this point the dip eastward is very slight; towards the Illinois coal-field, however, it is considerable, being from four to five hundred feet in sixty miles, and sufficient to bring the uppermost group down to the level of the Cumberland river, in Montgomery county. Towards the south and west, the dip of the "blue limestones" is greater than that of the "black slate" and the siliceous group above, thus making room for the Harpeth and Tennessee river group.

4. The groups enumerated above have been denuded in such a way as to form a *basin*, its outlines more or less obscured by "spurs," hills, &c., though, upon the whole, well defined; it is of an oval figure, about one hundred miles long and fifty or sixty broad, and runs somewhat obliquely across the state. (See map, Plate 7.) I have denominated it the *Silurian* basin, since the rocks of the entire area are of Silurian age, the "blue limestones," or groups first and second, being the surface-rock of the level and rolling lands constituting the *bottom* of the basin.

5. Along the western side, the upper part of the second, the whole of the third, fourth, and fifth groups crop out on the hill-sides or bluffs forming the walls of the basin. Group *third*, which is seen only along the western side, in sections, thickens as we proceed south-westward, and emerging in the counties of Perry, Wayne, Hardin, &c., from beneath the superior groups, which separate our basin from the bottom-lands of the Tennessee, becomes the surface-rock of these lands and the knobs along the river. On the south-eastern side of the basin, the slopes, bluffs, &c., present sections corresponding to those of the opposite side, with the exception of the *entire absence* of group *third*, or the gray limestones of the Harpeth and Tennessee rivers. (See section, on the map.)

6. The uppermost group, including all above the black slate, spreads out into a broad zone encircling the basin on all sides. It thus forms the "Barrens" and flat lands lying along and in front of the western slope of the Cumberland Mountains; running eastward it disappears beneath the *Pentremital* strata forming their base. (See map.) From the mountains, the zone sweeps off in a north-westerly, and then westerly course, through North-Tennessee and Southern Kentucky, presenting us again with barrens and flat lands. In this region, the Cany fork and Cumberland river, intersecting the strata deeply, have cut out for themselves narrow valleys, remarkable for their depth, their precipitous bluffs, and the beautiful waterfalls of their tributaries. Bluffs five and six hundred feet high have been reported.

The zone disappears in Kentucky, under the limestone slopes of the Illinois coal-field. From this region, it extends, rich in oxyd of iron, south through Tennessee, running under the cretaceous rocks west of the Tennessee river. The latter river and its tributary, the Duck, have here intersected the two topmost groups and exposed (§ 5,) the limestones below. The zone completes the circle, by sweeping off to the east in North Alabama, until it again reaches the mountains.

7. The groups and their members will be noticed in the ascending order, commencing with the lowest, as follows:

V. Siliceous Group, { *b*—Cherty limestone. / *a*—Siliceous beds.

IV. Black or bituminous slate.

III. Harpeth and Tennessee River or gray limestone.

II. Nashville Group, { *c*—Upper Nashville beds. / *b*—Lower Nashville beds. / *a*—Siliceous, or sandy limestone.

I. Stones River Group, { *c*—Upper Lebanon limestone. / *b*—Lower Lebanon limestone. / *a*—Stones River beds.

8. The rocks of Middle Tennessee, equivalent to the "Blue limestone" around Cincinnati, and to the Hudson River, Trenton and Black River Groups of New York, are about five hundred feet thick. They comprise the first two groups, which, though having characters in common, are upon the whole natural, and separated by a well defined horizon. The lower of these and the first of our series is the

I. *Stones River Group.*

9. This group is so named from the name of the stream along which it is finely developed. It is limestone throughout, and from 240 to 260 feet in thickness. We have divided it, for convenience, into three members, though a more natural arrangement would unite the first two.

10. (*a.*) *Stones River beds.*—This includes a series of blue and brownish-blue limestones, mostly fine-grained and thick-bedded, some strata of which abound in dark flinty layers. These rocks —the oldest of Middle Tennessee—are about seventy-five feet thick, and form an irregular circle, with a diameter of ten or twelve miles, constituting the summit of the denuded dome in Rutherford, (§ 3.) The member differs from the one next above in its thick-bedded strata, and in not affording as many fossils, which, (together with the comparatively less study bestowed upon it,) will account for the paucity of species. The following is a list of those observed and collected; it will be seen that nearly all are common to the member succeeding.*

1. Stromatocerium rugosum, Hall.
2. Orthis bellarugosa, Conrad.
3. Atrypa hemiplicata, Hall
4. " recurvirostra ? Hall.
5. Leptæna, allied to L. incrassata.
6. Pleurotomaria umbilicata, Hall.
7. Goniocerας anceps, Hall ?†
8. Actinoceras tenuifilum, Hall.

11. (*b.*) *Lower Lebanon limestone.*—The irregular circle just mentioned is surrounded by a broad *zone* of thin-bedded layers, which—everywhere attended by "cedar glades"—sweeps off in opposite directions, reaching the Cumberland on the north, and Duck River, along which it spreads, on the south. This thin-bedded sub-group is from fifty to sixty feet thick and is well developed in and about Lebanon, which locality has afforded most of the species enumerated. The sky-blue layers—sometimes separated by seams of argillaceous matter—are coarsely crystalline and abound in calcareous remains.

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* All of the species given in this paper, with very few exceptions, have either been collected, or seen by myself, in situ, and it affords me pleasure to state, that, in comparing and making them out, I am greatly indebted to the valuable assistance of so able a Palæontologist as Prof. James Hall.

† The relative abundance of species when considerable is expressed as follows—very abundant !!!—abundant !!—common !

List of Species.

1. Chætetes, n. sp.!! allied to lycoperdon.
2. " ? n. sp.
3. *Trematopora*, two new species.
4. Stictopora!! four or five n. sp's.
5. *Retepora fenestrata*, Hall.
6. Escharopora, n. sp.
7. *Graptolithus amplexicaulis*, Hall.
8. Schizocrinus, n. sp.
9. Fragment of a Cystidian, new genus.
10. " of a Sphæronites, n. sp.
11. Stems of Cystidiæ.
12. Leptæna incrassata, Hall!!
13. " sericea, Sowerby.
14. " filitexta, Hall.
15. " three sps. new and undeter.
16. *Orthis deflecta*, Conrad!!*
17. " *subæquata*, " !!
18. " *perveta*, "
19. " *tricenaria*, " !
20. " bellarugosa.
21. " sp.? allied to disparalis.
22. Atrypa increbescens?
23. " sp.? allied to recurvirostra.
24. *Ambonychia amygdalina*, Hall.
25. " *obtusa*, Hall.
26. *Edmondia ventricosa*, Hall.
27. *Maclurea magna*, Lesueur.
28. Pleurotomaria umbilicata, Hall!
29. Pleurotomaria subconica, Hall!
30. " *lenticularis*, Sowerby.
31. *Subulites elongata*, Conrad!
32. Holopea, n. sp.
33. " allied to obliqua.
34. Murchisonia bicincta, Hall!
35. *Cyrtolites compressus*, Conrad.
36. *Bucania bidorsata*, Hall.
37. " *expansa*, "
38. Carinaropsis, n. sp.
39. Endoceras proteiforme, Hall!
40. " n. sp.
41. Orthoceras fusiforme, Hall!
42. " multicameratum? Hall.
43. " undulostriatum? "
44. Actinoceras tenuifilum, Hall!
45. Gonioceras anceps, Hall.
46. Oncoceras constrictum, Hall!
47. Lituites, 2 n. sps.
48. Cyrtoceras, allied to arcuatum, Hall.
49. *Cytherina fabulites*, Conrad!!!†
50. Ceraurus pleurexanthemus, Green.
51. Calymene Blumenbachii, "
52. Illænus ovatus, Conrad.
53. " sp.?
54. Phacops callicephalus, Hall.
55. Isotelus megistos.
56. Tail of Lichas.

12. (*c.*) *Upper Lebanon limestone.*—The limestone last mentioned passes gradually into a heavy member of grayish, sometimes brownish, blue thick-bedded layers. Such is their character for the most part; within fifteen or twenty feet of the top, however, the layers become thin-bedded, interstratified occasionally with seams—rarely beds—of clay. The entire thickness is from one hundred and ten to one hundred and thirty feet.

This member runs in an irregular belt around the last, enclosing the inferior rocks and disappearing without, beneath the succeeding group. It forms, in addition, within the *belt*, the bases of two broken lines of ridges and hills—respectively the water-sheds of Stones River and the Cumberland, and of Stones and Harpeth on the north and Duck River on the south—thus cutting off the minor basin of Lebanon, and, east of Columbia, that of the Duck River.

The middle portion of the member is every where characterized by groups of *silicified Columnaria alveolata*, *Streptelasma profunda*, Hall, and the rough spherical masses *Stromatocerium rugosum*, to which we may add *Actinoceras tenuifilum;* fossils,

* O. deflecta has been described by Mr. Conrad, from an imperfect Wisconsin specimen, as Strophomena deflecta, and the same individual is figured in New York Pal., vol. i, under Leptæna; it is however a true Orthis.

† Cytherina fabulites, so far as I know, has never been figured; having seen Mr. Conrad's original specimen I can have no doubt as to its identity with mine.

however, are not very abundant, and hence our list is by no means as long as the last.

List of Species.

1. Stromatocerium rugosum, Hall !!
2. *Columnaria alveolata*, Hall !!
3. *Astrocerium*, n. sp.
4. Chætetes lycoperdon ? Hall.
5. " columnaris, "
6. *Streptelasma profunda*, " !
7. Clathropora, sp. undescribed.
8. Stictopora, two new species.
9. Atrypa recurvirostra, Hall.
10. Leptæna filitexta, "
11. *Pleurotomaria rotuloides*, Hall.
12. " subconica, "
13. Murchisonia bicincta, "
14. Actinoceras tenuifilum, " !!
15. Orthoceras anellum ?
16. " multicameratum ?

II. *Nashville Group.*

13. This group is not as easily subdivided as the last; the lowest portion, however, including from sixty to eighty feet, is a well characterized member; the remainder, which is about two hundred and sixty feet thick, not affording grounds for a positive division, has simply been divided equally into Upper and Lower Nashville beds.

14. (*a.*) *Siliceous or Sandy limestone.*—The aspect of this, the first subdivision of the group, is quite different from the purer limestone below; it is mostly a thick-bedded, coarse-grained, gritty, and, when freshly quarried, dark-blue, limestone. By weathering it loses its calcareous matter and becomes often a soft yellowish sandstone or shale.

This member abounds in individuals of *Orthis testudinaria*, which is highly characteristic, not having been noticed in any other position within the basin. This sub-group, forms a zone enclosing, and concentric with, those described.

List of Species.

1. Chætetes lycoperdon !
2. Leptæna, sp. !
3. *Orthis testudinaria* !!!
4. Atrypa increbescens.
5. Spirifer lynx.
6. *Small Acephal*, new !!
7. *Modiolopsis anodontoides.*
8. Holopea ? !

15. (*b* and *c.*) *Nashville beds, Lower and Upper.*—Succeeding the last, we have thick-bedded strata of blue and blackish-blue limestone running up into thinner layers, separated by seams, and rarely beds of shale. These rocks are generally granular, often gritty and impure, and prone to disintegrate.

About Nashville, there are two minor beds, which, though of limited extent, are of sufficient interest to be noticed. The first is a bed, at the base of the series, of light clouded blue limestone, from twenty to thirty feet thick, and extensively used for building. It is peculiar in being made up, as is shown on weathered surfaces, of finely comminuted fragments of shells, which, together with the oblique lamination observable, proves it to have been deposited from a strong current. This is followed by a few

strata of whiter, more compact limestone, in some places eight feet thick and not granular as the last. Above these, again, and separated by several feet of the ordinary limestone, follows the second interesting bed. It is peculiar in being of a yellowish gray color, in being almost entirely an aggregation of individuals of a *Bucania*, *Murchisonia bicincta*, and of fine specimens of an undescribed *Acephal*, and also in its porous character due to cavities formed by the grouping of the shells. The bed is from eight to ten feet thick and has been noticed by Dr. Troost in his reports.

In the following list of species, those which are confined either to the upper or lower part are distributed accordingly.

1. Streptelasma, sp. und. Upper.
2. Chætetes lycoperdon, Say. !!!
3. " *constellata*, Vancleve. Upper !!
4. " columnaris, Hall.
5. *Favistella stellata*, "
6. Receptaculites ? n. sp.
7. Astrocerium ? n. sp.
8. Stictopora, n. sp.
9. Stromatocerium, n. sp.
10. Schizocrinus (stems.)
11. *Cyathocrinites conglobatus*, Troost. Up.
12. *Asterias antiqua*, Troost. Upper.
13. Leptæna alternata, Conrad !!!
14. " sericea, Sow.
15. " planoconvexa, Hall. Upper.
16. *Orthis sinuata*, Hall. Upper !!
17. " *subjugata*, " " !!
18. " *pectinella*, Conrad.
19. " undescribed.
20. Spirifer lynx, Eich. !!
21. Atrypa increbescens, Hall. !!!
22. Atrypa modesta, Say !!!
23. *Ambonychia radiata*, Hall.
24. *Avicula demissa*, Conrad.
25. Two new gen. of Acephals.
26. *Pleurotomaria bilix*, Conrad.
27. " n. sp.
28. *Murchisonia bellacincta*, Hall.
29. " *subfusiformis*, Hall.
30. " bicincta, Hall. !
31. " sp. ?
32. *Bucania punctifrons ?* Conrad.
33. " n. sp.
34. *Cyrtolites ornatus*, Conrad.
35. Oncoceras constrictum, Hall.
36. " n. sp.
37. Orthoceras multicameratum ?
38. " lamellosum.
39. Gonioceras, n. sp. Lower.
40. Cyrtoceras macrostomum ? Conrad.
41. Actinoceras tenuifilum, Hall. Lower.
42. Cytherina, n. sp.

III. *Gray limestone, or Harpeth and Tennessee River Group.*

16. Here we reach a horizon wholly distinct in every respect from the last.

Along the southeastern escarpments of the basin, the *black slate* rests directly upon the layers of "*blue limestone*" containing Spirifer lynx and its associates, (§ 5.) Passing westward, however, the group under consideration intervenes, and thickens, as is shown by the bluffs of the Harpeth and Duck rivers, as we proceed. Thus, like a great wedge, it separates two groups, which are adjacent on one side of the basin, making them in fact unconformable. Along the Tennessee river the group is well developed. The "Cedar Glades" of Perry, Decatur and Hardin counties have become already, by the researches of Dr. Troost, classic ground to the Palæontologist. The group, no doubt, includes rocks both of Upper Silurian and Devonian age. In Sumner county, but a few feet below, the slate *Pentamerus oblongus* may be gathered in abundance, affording evidence that along the northern slopes the strata are mostly Upper Silurian.

If so, the Devonian division thickens towards the southwest. The thinning out of the strata and the commingling of the fossils render it difficult to make the separation.

The following is an approximate section of the rocks, along the Tennessee, commencing with the lowest.

First, a stratum of impure blue limestone, thin-bedded and fine-grained, of unknown thickness, forty or fifty feet of which are exposed in the bluffs and beds of several creeks in Hardin county. It is a good hydraulic limestone and is beautifully laminated in smooth layers, which are from one to five inches thick. It has afforded me, as yet, no fossils, and hence its age is uncertain.

Then follow from 100 to 130 feet of limestone, mostly light-gray and thick-bedded, containing crinoidal beds; some of the lower strata with bright green points; middle strata banded by *reddish* layers which are, generally, fine-grained, impure, cherty limestone, common on the Glades; upper portion sometimes affording bluish layers of siliceous limestone; all often of a marly nature, easily disintegrating, forming the angular gravel of the Glades and liberating their siliceous and calcareous fossils.

List of Species.

1. Astrocerium constrictum, Hall.
2. " venustum? "
3. " ? n. sp.
4. Lichenalia, n. sp.
5. Stromatopora, n. sp.
6. Ceramopora, n. sp.
7. Stictopora crassa, Hall.
8. Fenestella elegans, "
9. " tenuiceps? Hall.
10. " n. sp.
11. Favosites gothlandica, Lam.
12. " niagarensis, Hall.
13. Syringopora, n. sp.
14. Catenipora escharoides, Lam.
15. Streptelasma calicula, Hall.
16. " n. sp.
17. Cyathophyllum? three n. sp.
18. Cystophyllum?
19. Caryocrinus, Troost's sp's.
20. Pentremites Reinwardtii, Troost.
21. Balanocrinus sculptus, Troost.
22. Eucalyptocrinus, Troost's sp's.
23. Gilbertocrinus Americanus, Troost.
24. Platycrinus Ann Dixoni, Troost.
25. Cupellacrinus, sp's. of Troost.
26. Haplocrinus, " "
27. Leptæna depressa, Sowerby.
28. " subplana, Conrad.
29. Spirifer crispus, Dalman.
30. " undescribed.
31. " undulatus?
32. Calceola sandalina, Lam.
33. Atrypa obtuso-plicata, Hall.
34. " rugosa, Hall.
35. " lævis?
36. " three sp's. undes.
37. " aspera, Dalman.
38. " reticulatus, "
39. " Wilsoni, Sow.
40. Orthis elegantula, Dalman.
41. " hybrida, Sow.
42. " punctostriata? Hall.
43. Pentamerus oblongus.
44. " galeatus, Dalman.
45. Platyostoma niagarensis, Hall.
46. Phacops Hausmanni.

IV. *The Black Slate.*

17. This group, or stratum, cropping out around the escarpments of the basin, forms a well defined horizon. (See map.) It is already known, through the notices of Troost and others, as a brownish black slate, often bituminous, and containing iron pyrites, which is especially abundant near the base of the stratum. When exposed to damp air and at the same time protected from

rain, it is frequently encrusted with alum salts and copperas, due to the decomposition of pyrites.

In the northern part of the state, it is from forty to sixty feet thick, but thins out almost entirely towards the southwest; in many places often, as along Buffalo river, and in Hardin county, but a few inches of it are to be seen, sometimes scarcely a trace —a fact expressed upon the map by the broken part of the heavy line.

I have not been able to discover more than three small shells, of which but one has been well made out. In addition to the shells it occasionally affords fragments of leaves and wood. A *Lingula*, the shell referred to above, has been figured by Owen and Norwood in a pamphlet, entitled, "Researches among the Protozoic and Carboniferous rocks of central Kentucky." They consider it allied to L. spatula of the Genesee slate, though it is rather broader in proportion to its length. One of my specimens is a new species of *Chonetes;* it was obtained, together with the others in Maury county.

V. *Siliceous Group.**

18. This series—the "siliceous stratum" of Dr. Troost—included between the black slate and the pentremital limestone, is well marked throughout by its siliceous characters.

There appears to be doubt as to the age of the lowest beds, some regarding them as Devonian, others as carboniferous; we are inclined to adopt the latter view, and have upon the map regarded the entire group as carboniferous. The species are certainly closely related to carboniferous types.†

19. This series has been divided into two members.

(*a.*) *Siliceous beds.*—This member, including in the northern part of the state about 200 feet, appears to have had partly a chemical, and partly a mechanical origin. It consists mostly of a fine-grained, siliceous rock—sometimes approaching a fine sandstone; when freshly quarried, it is of a light blue color, and compact; it contains but little calcareous matter, and is often interstratified with layers of hornstone or flint;—occasionally beds of bluish siliceous shale are met with. Upon exposure, the rock, especially when more than usually calcareous, decomposes, losing its blue color and becoming a soft, mostly yellow, sometimes grayish, sandstone or shale. The Lebanon and Sparta turnpike exposes an entire section at Snow's hill, which

* This interesting series requires far more study than has been bestowed upon it; the fossils especially, excepting the Crinoids which Dr. Troost has described, are new and need to be worked out. I trust, however, that the following notice made out mostly from personal observations may add something to what was before known of these rocks. See, in addition, Troost's reports.

† See Researches of Owen and Norwood before referred to.

is, from top to bottom, soft, yellow, siliceous or sandy shale, with heavy interstratified layers of hornstone.

The rock is generally thinly *dotted* with siliceous—sometimes calcareous—concretions; the larger occurring in the upper, more calcareous portion, are often fine geodes of quartz lined with crystals; one locality, at least, affords rhombohedral forms.

An interesting feature of these rocks—in fact of the group—is the presence of *Crinoidal limestone.* It occurs at various elevations in intercalated beds, ranging from one to ten feet in thickness; some of these are pure grayish-white limestone made up of the crinoidal remains; others are impure and enclose silicified fossils. As might be anticipated, the Crinoids are the most abundant fossils. The silicified ones are found occasionally in place, but usually detached, on the hill-sides with the flinty fragments, and in the soil; silicified *Trochites* of a large size, both circular and oval,—common also to the succeeding member,—are found in many places.

Large *Spirifers* and *Producti* occasionally occur, but excepting perhaps Crinoids, fossils are not abundant, the conditions under which the rocks were deposited not having been favorably to animal life.

List of Species.

1. Cyathophyllum, sp.?
2. Streptelasma, n. sp.
3. Actinocrinus Agassizii, Troost.
4. " urna, "
5. " cornutus, "
6. " Humboldtii, "
7. " Marineri, "
8. " Nashvillensis, "
9. " fibula, "
10. Synbathocrinus Tennesseæ, Troost!
11. Catyllocrinus Tennesseæ, "
12. Cyathocrinus pentasphericus, "
13. " corrugatus, "
14. Conocrinus tuberculosus, " !
15. Agaricocrinus tuberosus, " !
16. Spirifer allied to attenuatus.
17. Producti and other shells not described.

As we approach the topmost strata, the rocks, without affording any well marked limit, gradually run into

20. (*b.*) *Cherty limestone.*—This member though related to the last, differs in being a true limestone, in affording a brick-red soil, in the character of its imbedded masses, and in being much more fossiliferous. The fundamental rock is thick-bedded and impure, of a light blue color; it occurs occasionally in purer beds without flints, but, in the main abounds in reniform nodules of chert and in siliceous layers. The latter, which, by the way, are very characteristic, liberated by the removal of the calcareous matter that contained them, occur very generally on the surface and in the red soil, in rough *friable* masses having a *porous* sandy structure and a light yellow or gray color; they abound in species of the beautiful *Fenestella*, and often in a large undescribed (?) Orthis, as well as in other species.

The strata are sufficiently argillaceous to give the soil a clayey consistence.

A most important economical feature of these rocks is the presence, especially westward, of iron ore which sometimes passes down into the member below. The soil everywhere contains sufficient oxyd of iron to color it deeply.

This member is mostly the surface-rock of the table-lands surrounding the basin, and usually appears a few miles in the rear of the escarpments, increasing in thickness as we approach the mountains on the east, or the hilly ridges of Southern Kentucky on the north and northwest. (§ 6.)

From my own observations, and the best data I can collect, I infer the member to be from 250 to 300 feet thick, making the entire group 450 or 500 feet.

Owing to the present imperfect state of our knowledge of American carboniferous species, it is impossible to give a satisfactory list. The following is presented.

1. Syringopora reticulata, Gold.?
2. Lithostrotion, sp.?
3. Cyathophyllum, sp.?
4. Fenestella retiformis, Schlot.? and other species.
5. Synbathocrinus Tennesseæ, Troost!
6. Agaricocrinus tuberosus, " !
7. Conocrinus tuberculosus, " !
8. Granatocrinus cidariformis.
9. Platycrinus Saffordi, Troost.
10. Productus cora, A. d'Orb. and other sp's.
11. Spirifer, several sp's.
12. Orthis, " "
13. Terebratula serpentina, d. Kon.
14. Pleurotomaria, sp.?
15. Euomphalus, three sp's.
16. Bellerophon, sp.?
17. Acephala, several genera.

Art. XXXVII.—*On the Houghite of Prof. Shepard;* by S. W. Johnson, of the Yale Analytical Laboratory.

Read before the Am. Assoc. for the Advancement of Science, at Albany, Aug. 1851.

On page 314 of the Proceedings of the meeting of this Association held at New Haven last year, occurs a notice of the mineral Houghite by Prof. Shepard. More than two years since I noticed specimens of this mineral from Dr. Hough, and then purposed to examine it. The specimens which were in my possession at the time of the publication of Prof. Shepard's paper, and which furnished the material for my analyses, agree in the main with his description; and it appeared improbable that any chemical species could be made from them as they were exceedingly variable in composition as well as in appearance. It commonly occurs as small imbedded nodules, usually more or less flattened, with the interior dark gray or bluish gray and the exterior white.

Experiment and observation unite in proving that the difference in color between the external and internal portions of these "concretions" is due to difference of composition. The milk-white parts contain *carbonic acid*, the bluish-white portions do not. Further, some specimens are milk-white throughout, while others are almost entirely of a bluish tinge, and semitransparent. The specimens at my command for analysis were uniform in ap-

pearance, but were more or less opake white externally and without exception were pervaded by minute grains of spinel and phlogopite. Some of them presented a portion just within the opake layer, that was transparent and homogeneous: within this, fragments and crystals of spinel predominated. These statements are necessary as a preface to the account of my chemical investigations, after detailing which, the physical properties will be again referred to.

The mineral subjected to analysis, comprised fragments partially opake and partially translucent, as it was almost impossible to procure by separation a homogeneous material. After ignition, it manifests an alkaline reaction, and this, as I have since found, it also does before heating.

As stated by Prof. Shepard, it is decomposable in acids, before and after ignition. A large nodule, slowly dissolves, even in cold acetic acid. Carbonic acid is evolved during solution, and in sufficient quantity to produce a precipitate on passing through baryta water. A residue has always occurred in my experiments, consisting in part of insoluble minerals,—spinel and phlogopite, and also in most cases of silica; and in fact, the mineral has often afforded a well characterized jelly with acids. The acid solution gives with ammonia, in presence of chlorid of ammonium, a copious white precipitate. The filtrate contains only magnesia, or occasionally a trace of potash, possibly from decomposition of phlogopite. The ammonia precipitate, as noticed by Prof. Shepard, yields alumina and a trace of iron to caustic potash, but is not entirely decomposed even by a large excess of it, during protracted digestion at a boiling heat. Following the usual routine of analysis it was repeatedly, and most carefully examined for all the salts and rare earths that can occur in such circumstances, but no evidence of their existence was obtained. It appeared to be a hydrous compound of magnesia and alumina, and upon reference to Gmelin's Handbuch, notice of such a substance was found. By three or four repeated solutions in hydrochloric acid, and precipitations by ammonia, it was completely separated into the two earths, alumina and magnesia; which with water completed the sum of its ingredients.

Previous to entering on the quantitative investigation of this mineral, I made inquiries of Dr. Hough, who resides near the locality, hoping to obtain homogeneous specimens. He could not furnish them, and the following analyses were made without expectation of perfectly accordant results.

In the analysis, carbonic acid was determined, in the usual manner, in a flask furnished with chlorid of calcium and aspirating tubes. Water was expelled by ignition, and collected in chlorid of calcium. The mineral was decomposed in hot hydrochloric acid, the whole evaporated to dryness, redissolved, and filtered;

in the solution, alumina and magnesia were separated by bicarbonate of soda; the magnesia weighed as pyrophosphate, the alumina, as such, after solution and reprecipitation by carbonate of ammonia. The insoluble residue was treated with hot solution of carbonate of soda, to extract silica.

Before subjecting the mineral to analysis, a portion in small fragments, the most homogeneous that could be selected, was used for determining its specific gravity. For this purpose after its weight had been taken, it was boiled in the water in which it was subsequently weighed, as air bubbles adhered to it very pertinaciously. The number 2·175 was obtained; but the mineral was afterward found to contain spinel.

A quantity of the mineral after being pulverized, was placed in a Liebig's drying tube, and exposed in a current of dry air to a heat of 100° C.; it lost water for a long time. The heat was afterward raised to 175° C., and it continued to lose weight for several days. It was finally submitted to the highest temperature admissible in an oil-bath, 280° C. (536° F.), and after more than 100 hours of drying, it ceased to lose weight. As this result had not been foreseen, the original weight of the mineral was not taken; the loss was at least five per cent.

In this dried portion were found

Ȧl	Ṁg	Ḣ (by diff.)	C̈	insol. (Spinel, &c.)	Silica.
19·743	36·292	24·223	8·458	8·264	3·020=100.

A fresh portion of the mineral including that employed in taking the specific gravity, was carefully intermingled, pulverized and dried over SO_3 *in vacuo*.

Two determinations of carbonic acid gave respectively 6·712 and 8·094 per cent.; mean, 7·380 per cent. Another portion, the only remaining material, was ignited until it ceased to lose weight. It then contained no carbonic acid. The loss was 40·857 pr. ct. It was analyzed with the following results.

Ȧl	Ṁg		
30·048	55·467	insol. (spinel and mica) 15·196,	Silica, *trace* =100·711

Several water estimations were made, varying from 33 to 41 per cent., but I attach no value to them. If we subtract 7·380 the mean result for carbonic acid from 40·857 the total loss on ignition, we obtain 33·477 as the per-centage of water; rejecting the insoluble minerals and calculating the remaining constituents on 100, the composition stands as follows:

Ȧl	Ṁg	Ḣ	C̈
23·867	43·839	26·452	5·833 = 99·995

Excluding, in both analyses, all the ingredients but alumina and magnesia, and reducing these to per-centage relations, we find the following numbers.

	1st Analysis.	2d Analysis.	Mean.
Ȧl	35·238	35·137	35·185
Ṁg	64·763	64·862	64·812

These accordant results indicate the existence of definite relations between these two ingredients. Divison by the equivalents, gives the ratio of 4 of alumina to 19 magnesia, corresponding to alumina 35·15, magnesia 64·85. The ratio of 1 : 5 would require alumina 33·53, magnesia 66·47.

It seems useless to speculate on the constitution of Houghite without new analyses.

Quite recently, I have visited the locality in company with Dr. Hough. It is in the town of Rossie, and near the village of Somerville, in St. Lawrence county, N. Y. The mineral occurs disseminated through white crystalline limestone, at the summit of a slight elevation, near which occurs beds of the Potsdam sandstone. Associated with Houghite are dolomite of variable composition, scapolite of brown and green color, phlogopite, graphite, spinel, and a crystallized pseudomorphous (?) yellow serpentine, in which I have obtained the water and silica percentages of that mineral.

Much of the rock exhibits evidences of atmospheric action. The serpentine in the altered parts has become discolored and so friable as to yield to the pressure of the fingers. The nodules of Houghite are half exposed, easily detached from the rock, and often opake and milk-white throughout.

This altered or bleached appearance in the rock does not occur upon the uppermost surface, as far as I have observed, but along its sides and under portions pendant over a cavity. But not a nodule of Houghite has been found even in the least altered rock that has not presented superficially in some parts a milk-white color.

Among the masses which furnished material for analyses, I found several specimens that exhibited unequivocal evidences of octahedral crystallization, one of which is here represented. Some of them are ⅜ths of an inch in diameter; they are superficially grooved and contorted, their edges are rounded, and protrude beyond the planes of the faces. In some an appearance occurs, which seems as if it had been produced by a protrusion, near the edge of each plane, leaving a line of depression with reëntering surfaces, corresponding to the lateral edges of a perfect octahedron, while on the faces, a triangular depression occurs, bounded by the protruded edges of each plane of the crystal. In one nodule there is a gradual transition from the soft and amorphous Houghite, to the hard and regularly terminated spinel. The crystals are occasionally compound.

In another specimen, in Dr. Hough's collection, there were the summits and faces of several perfect octahedrons. The solid angles had the hardness and lustre of spinel; but portions of the faces were destitute of lustre, or only glimmering, from disseminated particles of spinel, and were easily scratched by the knife. This specimen consists of three almost perfect crystals, each about $\frac{3}{4}$ths of an inch in diameter, besides three of smaller size. The whole was imbedded in serpentine and dolomite. These crystals are formed of mixed spinel and Houghite. The spinel seems to predominate on the edges and solid angles; but some of the well defined edges yield to the knife. When a crystal is held so as to reflect light to the eye, it is very easy to distinguish the two minerals. It is seen that they are irregularly disposed, and yet follow certain lines of cleavage which are not parallel, often curved and generally unsymmetrical with the figure of the crystal. They seem free from the milk-white color which is observed in the amorphous masses, and no doubt contain the true specific Houghite. In another large octahedral crystal of regular form, the exterior is whitened and altered to the depth of half a line.

Many interesting facts and speculations have occurred to me in relation to the origin of this mineral. Its association with spinel as well as the similarity to that mineral in the bases in its composition, are facts of great interest. It might appear that they were simultaneously formed, since they occur together, in such intimate mixture, and yet are so well defined. Possibly when the spinel has predominated to a certain extent, or been placed in otherwise favorable conditions, its crystallizing force, in causing it to assume its own peculiar form, has impressed that form on the Houghite, analogous to what has occurred in the Fontainbleau limestone. But there are objections to this view, since spinel, according to the experiments of Ebelmen, is of purely igneous origin, and the circumstances attending its formation are incompatible, as far as we know, with the simultaneous production of a hydrous mineral.

[*Note on the probable Identity of Houghite and Völknerite.*—Mr. Johnson has observed that we cannot obtain from the analyses a satisfactory view of the composition of the mineral, owing to the uncertain results. The analyses are still sufficient to authorize the suggestion that Houghite, when pure and free from carbonic acid, may be identical with the *Völknerite* of Hermann.* Hermann obtained for the Völknerite,

$$\dot{\text{Al}}\ 17{\cdot}65, \quad \dot{\text{Mg}}\ 38{\cdot}59 \quad \dot{\text{H}}\ 43{\cdot}76$$

This gave Hermann for the oxygen of the alumina and magnesia the ratio 1 : 2, [more exactly 1 : 1·84] while the analyses of

* Journ. f. prakt. Chem., xl, 11, and Dana's Mineralogy, 3d edit., p. 201.

Houghite rather favor the ratio 1 : 1½. The approximation shows at least the close relation of the two minerals. As part of the water of constitution was evidently driven off by excessive heat in drying, the per-centage of this ingredient is yet to be ascertained. The grayish mineral forming the interior of the masses is not foliated like Völknerite, but this structure may not be more essential here than it is in gypsum. The nodules are often somewhat fibrous radiated. The presence of carbonic acid in the exterior of the nodules is apparently due to an alteration of the true hydrous mineral, from the action of the carbonic acid of infiltrated waters or the atmosphere. The hydrotalcite of Hochstetter, which Hermann refers to Völknerite, afforded 10·54 p. c. of carbonic acid.*

The mineral has probably resulted from the alteration of spinel, judging from the many specimens the writer has seen. There is a passage from the perfect octahedrons with sharp edges, to those that are uneven and rounded as if by corrosion from chemical action, and from these to the flattened nodule; and the nodules are such forms as would result from a softening and pressure accompanying the metamorphic change, together with the crystallizing or semi-crystallization of the new mineral.

J. D. D.]

ART. XXXVIII.—*On some of the Thermal Waters of Asia Minor;* by Dr. J. LAWRENCE SMITH, of New Orleans, Prof. Chem. in the University of Louisiana.—Part II. *Waters of Yalova, Hierapolis, Eski-shehr, Troy, Mitylene and Tiberias.*

Thermal Waters of Yalova.†

THE shortest way of reaching the springs of Yalova is by landing on the south side of the Gulf of Nicomedia, near to *Angori*, (three hours distant from Constantinople by steamer,) and proceeding along a beautiful plain, that gradually narrows until terminating in a valley closely shut in by hills. The springs in question are situated in this valley, about six miles from the sea; they are at the foot of a hill, which on the southwest closes in the valley of Yalova and are known in the country by various names, as *Couri-Hamam*, *Dagh-Hamam*, &c.

On the road that approaches the springs, there are extensive remains of the foundations of old Roman and Grecian buildings, and still nearer, the remains are more perfect, in the form of arches,

* See Dana's Mineralogy, p. 201.

† The locality of these waters is described very fully as it is but little known, being seldom visited by travellers.

aqueducts, baths, &c. Their extent gives evidence of the celebrity they enjoyed in former times. The styles of their architecture belong to different periods. The remains of the brick edifices are evidently of the period of the Lower Empire, for on many of the bricks are to be found an impress of the cross, and Latin words written in Greek letters. To judge from the form of these letters, particularly the epsilons, sigmas and omegas, one is led to believe that they date from the Justinian age. The massive stone arches, which support the vault under which the waters rise, seem to have been constructed by the Romans. Their structure presents nothing which opposes the idea received by the inhabitants of the surrounding villages, namely, that they were constructed during the reign of Constantine the Great. And what seems to sustain this hypothesis, is, the popular legend that the mother of Constantine was indebted to these waters at one period of her life, for her restoration to health; and from this fact (according to the authority of the celebrated archæologist, the Patriarch of Constantius) Yalova was formerly called Helenapolis.

In want of more exact data we may cite as sustaining this supposition, the custom of the Greek villagers of the neighborhood, kept up for many centuries, of assembling at these baths on the anniversary of the *fêtes* of St. Constantine and St. Helena, to celebrate the virtue of these waters. Von Hammer in his history of the Turkish Empire, alludes to this place in the following words: "Some leagues from *Cara-Mursal* on the south side of the Gulf of Nicomedia, there exist the baths of Yalova (ancient Sergla or Trepanon). This place was adorned with a great number of palaces and hospitals by the Empress Helen, whose father had kept an inn there. This place was afterwards raised to the rank of a city by Constantine, the founder of the Byzantine empire, and called Helenapolis in honor of his mother. It was to this place that the first army of the crusaders, conducted by Peter the hermit and Gautier *sans-avoir*, took refuge after being routed near Nice. It was here also that the Saracens constructed pyramids and towers with human bones. Helenapolis has been at all times celebrated for its thermal waters. Near their source is to be seen the tomb of an *Abdal*, that is, an enthusiastic dervish, who armed with a wooden sword undertook at the head of a body of Mussulmans to conquer this city."

There are several ancient authors who allude to these springs, among whom are Ammianus, Marcellinus, Mela, and Anna Commenus.

Yalova, which is now but a small village, was formerly the place of debarkation for the inhabitants of the celebrated cities of Nicomedia, of Nicea, and of the numerous cities of Bithynia, who visited these springs. The port of Couri, whose antiquity is

indicated by several Greek inscriptions, was probably, as now, frequented by those coming from Constantinople and other cities of the Propontide.

After the fall of the Roman empire, these baths went to ruin, and were almost forgotten; nevertheless the reservoirs and aqueducts remain as in the time of the Lower Empire. It is only a few years since an Armenian banker purchased the place and constructed houses for the reception of the sick.

These waters have at least *nine* sources. They flow from the sides and bottom of a hill, rising through a sandy bottom accompanied with bubbles of gas, and differ but little in their temperature and composition. The character of the surrounding rocks is not easily made out; I am inclined to refer them, from my observations higher up the gulf, to the older tertiary. The waters in their course leave not the slightest deposit, so that the ancient aqueducts have never become obstructed.

According to the accepted classification, the mineral waters of Yalova belong to the *hot sulphurous waters*. They have at their source a very slight odor of sulphuretted hydrogen, but the quantity is so small, either in the water or the gas, that it could not be estimated. The temperature of the waters is from 151° to 156° Fah., and varies but little with the changes of the atmospheric temperature. The water is limpid and transparent, and has the specific gravity 1·00115.

The gas which escapes at the source gave on analysis,

Nitrogen, - - -	97 per ct.
Oxygen, - - -	3

One litre of the water gave 1·461 grammes of solid matter. —The same quantity of water contains in grammes,

Sulphuric acid, . .	·690	Magnesia, . . .	·002
Chlorine, . . .	·086	Alumina, . . .	*trace*
Soda, ...	·393	Silica, ...	·035
Lime, ...	·208		

Combined in the following manner:—

Sulphate of soda, . .	·807	Sulphate of magnesia, .	·005
Sulphate of lime, . .	·414	Sulphate of alumina, .	*trace*
Chlorid of sodium, .	·072	Silica, ...	·035
Chlorid of calcium, .	·068		

The composition of these waters resembles that of the Bath waters of England, the latter however not being of so high a temperature. They act powerfully on the nervous system and on the secretions and excretions, particularly those of the skin; which renders them so efficient in rheumatism, gout, &c.

Thermal Waters of Hierapolis.

The ruins of the ancient city of Hierapolis are among the most interesting in the southwestern part of Asia Minor. The place is situated about six miles from Laodicea (one of the seven churches) and about one hundred and ten miles from Smyrna. The site is seen for many miles before it is reached, as it rises abruptly from the north side of an extensive plain, and the sides of the hill are covered with an incrustation of dazzling whiteness for upwards of a mile in length, and from this it has received its present name, Pambuk-kelesey, (cotton castle.)

This place was much admired in former times, if we are to judge from the inscriptions still to be seen on different parts of the ruins, to the following effect. "Hail, golden city, Hierapolis; the spot to be preferred before any in wide Asia; revered for the rill of the nymphs, adorned with splendor;" the people, in some of these inscriptions, are styled, "the most splendid," and the senate, "the most powerful."

It is a place well known to travellers in this part of the world, and therefore I shall confine myself strictly to what concerns its thermal waters, which have ever been its principal object of note, as evinced by the extensive ruins of baths. In fact the very hill upon which the city stands owes its formation to the deposition of carbonate of lime from these waters, and it now rises upwards of a hundred feet above the plain with a width of about six hundred feet. Immediately behind the city, rises another set of hills of calcareous rock, from which flow the waters in question; they first enter a large pool in front of the theatre, and from this the water flows in numerous little streams that course in channels made by incrustations from the water. The amount of water is very great, and it is so highly charged with carbonate of lime, as to incrust all bodies that it comes in contact with, and it takes place so rapidly that the concretion does not possess great solidity, and frequently has a granular form resembling driven snow.

It is this incrustation, as I before said, which gives to the immediate site of the city its remarkable character. In some places as the waters flow over the steeply inclined sides of the hill, it forms a succession of terraces at regular distances, that require but little effort of the imagination to liken to an amphitheatre with its marble seats. At other places, it flows over the precipitous sides sixty or seventy feet high, and one or two hundred feet wide, incrusting the precipice with a snow-white sheet which might be likened to a consolidated cataract, and what adds to the delusion, at the base the incrustations have accumulated an irregular mass not unlike foam. This petrified stream extends several hundred feet into the plain. It has formed walls and

dikes, and incrusts the grass and vegetation that it flows over, and many of the tufts of grass, in perfect verdure, are thickly incrusted near the roots with this white carbonate of lime.

The channels that conduct the water through the city are made by deposits from these waters; many of them are very deep and almost arched over. The incrustations in and about the city have elevated the level of it some fifteen or twenty feet, since its destruction. Strabo tells us, that in his day the people of this city conducted these waters into their gardens or other places where they desired to form a wall, and in a short time they obtained fences of a single stone, so rapid was the deposition. The road which leads from the plain to the city is a causeway which is formed entirely from the water.

Physical Properties.—The water is of remarkable transparency, and remains so after being kept for any length of time. Having lost my thermometer the day before arriving at this source, I was unable to ascertain its exact temperature. I judged it to be about 130° Fah. Specific gravity, 1·00143.

Chemical Properties.—Solid contents in one litre, 1·934 grammes. One litre contains in grammes:

Carbonic acid, free,	·352	Potash,	*trace*
Carbonic acid, fixed,	·462	Lime,	·589
Sulphuric acid,	·541	Magnesia,	·164
Chlorine,	·012	Silica,	·008
Soda,	·182	Phosphoric acid,	·005

The combination of acids and bases may be represented in the following manner.

Bi-carbonate of soda,	·078	Sulphate of lime,	·119
Bi-carbonate of lime,	1·368	Sulphate of magnesia,	·431
Bi-carbonate of magnesia,	·041	Phosphate of lime,	·012
Chlorid of calcium,	·020	Silica,	·008
Sulphate of soda,	·341		

The *incrustation* of the spring was analyzed; it is remarkably white, and almost pure carbonate of lime. The composition is as follows.

Carbonate of lime,	98·2
Silica,	00·6
Magnesia, Phosphate of lime, Fluorid of calcium,	1·2=100·0

At the present day these waters are not used, and the neighboring country is quite deserted, with the exception of a miserable village of some half dozen huts. In former times, however, beside the use of this water for the baths, it was greatly in repute

among the dyers in a purple color made from a kind of root, and owing to the remarkable adaptation of this water for that purpose, the tint obtained is said to have rivalled the more costly purple, and to have constituted the principal source of riches to the city. The company of dyers is alluded to in the inscription on a square building among the sepulchres. These waters also seem to have possessed medical virtues, if we are to judge from some of their medals, on which you find Apollo (the tutelar deity of Hierapolis) with Æsculapius and Hygeia.

Strabo alludes to a circumstance connected with these waters that I inquired into while there, but without success. It is the existence of what that author calls a *Plutonium*, described as an opening about the size of a man in the side of the hill, with a kind of enclosure of half an acre in front of it; from the opening there issued constantly a dark vapor, that filled the enclosure in front of it. He states that all animals entering this enclosure became suffocated, but that the sacred eunuchs who attended in the temples could enter with impunity.

I sought to discover this *plutonium* but without success, it was doubtless an opening in the rock, from which issued a mixture of carbonic acid and vapor of water, that has subsequently become obstructed.

Thermal Waters of Eski-Shehr.

Eski Shehr is the ancient Dorylæum, the plains of which are very extensive. It is mentioned by the Byzantine writers as the field of the first battles between the soldiers of the Eastern empire and the Turks. It is situated on the river Pursceck or Thymbius, which empties into the Sangarius, that flows into the Black Sea, and is equidistant from that sea and the sea of Marmora, being a little over one hundred miles from each.

Eski-Shehr is a city of some importance to the Turks, and it is from here that Europe derives the greater portion of that mineral called Meerschaum, used in making pipes.

In a certain quarter of this city, by excavating to the depth of a few feet, hot water is obtained, which is a matter of great annoyance to the inhabitants, as they can have no wells of drinking water. It is in this quarter that are situated the celebrated hot baths, doubtless used for more than two thousand years, with such change in structure as time and the habits of the people required. There is here a large excavation sixty or eighty feet square, closed in with stone and roofed over; its depth I did not measure, but am told that it is twelve or fifteen feet. The water arrives from many sources at the bottom of this reservoir.

The reservoir was made by the Greeks and repaired some years ago by the Turks. The amount of water furnished is

very great, and forms half the water used in turning a mill in the neighborhood.

The water is allowed to flow from the great reservoir into a large Turkish bath, as well as from different hydrants for the purpose of washing dyed stuffs, &c.

Physical Properties.—This water is clear and transparent, and when cold it is very agreeable to the taste; no gas escapes from it, nor is there any deposit, even after very long repose. Temperature 119° Fah. Specific gravity 1·00017.

Chemical Composition.—The solid contents in one litre ·260 grammes. One litre of the water contains in grammes—

Carbonic acid, free, .	·118	Soda with a little potash,	·119
Carbonic acid, fixed, .	·195	Lime, ...	·040
Sulphuric acid, . .	·030	Silica, ...	·008
Chlorine, . . .	*trace*		

Combined as follows:—

Bi-carbonate of soda, .	·219	Sulphate of lime, .	·029
Bi-carbonate of lime, .	·078	Chlorid of calcium, .	*trace*
Sulphate of soda, .	·021	Silica, . . .	·008

As is seen by the analysis, this water is remarkably free from solid matter, nor is it supposed by the inhabitants of the country in its neighborhood, to possess any other than the ordinary properties of water.

The geological character of the contiguous country has nothing in it that would induce one to suspect the existence of such abundant sources of warm water. The plain of *Eski-Shehr* appears to be one of those extensive lacustrine regions so common in the western portion of Asia Minor; the deposits consist of a consolidated breccia. Imbedded we find the rocks of the neighboring mountains, as well as the Meerschaum or silicate of magnesia, so extensivly worked for exportation. Thermal waters are obtained in numerous parts of the plain as well as at Eski-Shehr.

Thermal Waters of Troy.

Near the plains in which are supposed to have been situated the ancient city of Troy, are numerous sources of thermal waters, of several of which I procured specimens; only two, however, have been analyzed, the others not having arrived at my laboratory. These springs are those alluded to by Homer, and they have enjoyed more or less reputation from the time of the Trojans to the present date. The two that I have examined are saline and their sources near each other. Analysis shows them to be identical. The physical properties will be alluded to when the other waters from this locality have been examined.

Chemical Composition.—One litre contains of solid matter 21·301 grammes. The same quantity of water has in its composition

Carbonic acid, fixed, .	·0595	Lime, . . .	1·4000
Sulphuric acid, . .	·0680	Magnesia, . . .	0·3012
Chlorine, . . .	12·8000	Oxyd of iron, . .	*trace*
Bromine, . . .	*trace*	Silica, ...	0·0600
Soda, . . .	9·2110		

Combined as follows:—

Carbonate of lime, .	·1225	Chlorid of magnesium,	·7031
Sulphate of soda, .	·0607	Bromid of magnesium,	*trace*
Sulphate of lime, .	·0540	Chlorid of iron, .	*trace*
Chlorid of sodium, .	17·4450	Silica, . . .	·0600
Chlorid of calcium, .	2·5078		

Thermal Waters of Mitylene.

On this island, the ancient Lesbos, there are several warm springs, and much of the geological structure of the place is volcanic. I visited two of the springs; the first is near to the village of Mitylene, and immediately on the shores of the gulf of Olives, it is called *Kelemyeh Oulinjah*, and there are two baths attached to it.

Kelemyeh Oulinjah source.—The water is clear, and flows without leaving a deposit. Its temperature is 102° Fah. (atmosphere at 77°), and when cold there is nothing marked in its taste.

Chemical Composition.—There are 1·250 grammes of solid matter in a litre of the water which contains the following ingredients in grammes.

Carbonic acid, free, .	·155	Soda, ...	·278
Carbonic acid, fixed, .	·075	Lime, ...	·152
Sulphuric acid, . .	·040	Magnesia, . . .	·070
Chlorine, . . .	·570	Silica, ...	·015

Combined as follows:—

Bi-carbonate of lime, .	·2450	Chlorid of calcium, .	·0865
Sulphate of soda, .	·0357	Chlorid of magnesium,	·1628
Sulphate of lime, .	·0330	Silica, . . .	·0150
Chlorid of sodium, .	·6510		

The other source visited on the island of Mitylene is about six miles north of the village, and is called *Touzla;* there are baths attached to it, and the waters are strongly saline.

Touzla source, (saline.)—*Physical Properties.*—The water does not flow clear, being more or less tinged with yellow produced by some organic acid in combination with lime. This deposit is seen to mark the course of the water as it flows down

the beach into the sea which is very near to it. Temperature of the water 117° Fah. (atmosphere at 76°.) Sp. gr. 1·0263.

Chemical Composition.—There are 34·520 grammes of solid matter in a litre of the water which contains the following ingredients in grammes:—

Carbonic acid, fixed, .	·050	Lime, . . .	2·534
Sulphuric acid, . .	1·648	Magnesia, . . .	0·110
Chlorine, . . .	18·440	Alumina, . . .	0·012
Bromine, minute quantity not estimated.		Iron, ...	0·003
		Soda, ...	14·858

Combined as follows:—

Carbonate of lime, .	·0912	Chlorid of calcium, .	2·0040
Sulphate of soda, .	1·4625	Chlorid of magnesium,	0·2023
Sulphate of lime, .	1·3000	Carbonate of iron, .	0·0038
Sulphate of alumina, .	0·0221	Bromid of magnesium, minute quantity.	
Chlorid of sodium, .	28·0260		

There are several other sources of thermal water in various parts of this island; the one reputed to have the greatest temperature is about eighteen miles from the latter, and called *Fezilkeh;* this source I could not visit, and can therefore say nothing of it from personal examination. There is yet one other source that I will allude to, the

Tiberiad Thermal Waters.

The source of these waters is on the border of the sea of Galilee and within a mile of the city of Tiberias, of the solid structure of which, repeated earthquakes have left but little. The surrounding country show marked evidence of extensive volcanic action.

There are several sources at the place I visited, but they seem to vary little from each other. They flow into Turkish baths, and from them pass into the sea, on their way leaving a slight yellow deposit which is doubtless, as in many of these waters, a crenate of lime.

Their temperature was not accurately ascertained for want of a thermometer, but I should consider it about 120° Fah.

Chemical Composition.—In one litre 23·540 grammes of solid matter. The same quantity of water furnished in grammes:

Carbonic acid, fixed, .	·006	Lime, . . .	·443
Sulphuric acid, . .	·197	Magnesia, . . .	·119
Chlorine, . . .	13·989	Silica, . . .	·006
Soda, ...	8·751		

Combined as follows:—

Sulphate of soda, .	·0620	Chlorid of calcium, .	·7801
Sulphate of lime, .	·0386	Chlorid of magnesium,	·1850
Sulphate of magnesia,	·0151	Silica, . . .	·0060
Chlorid of sodium, .	22·2330	Carbonate of lime, .	·0106

The quantity of water brought away was too small to examine for the presence of bromine.

This is the last of the thermal waters of Asia Minor which have been examined; there are a few others that may yet reach me, when the composition will be made known as soon as examined.

Cause of the Thermal Waters in Western Asia Minor.

The cause of the abundance of warm springs in this quarter of the globe, in all formations from the alluvial to the oldest rocks, is doubtless owing to the extensive igneous action within no great depth beneath the surface of the country; a fact evinced by the frequency of earthquakes, but more especially by their extent; for they almost invariably extend from one end of it to the other, as well as to the neighboring islands.

Neither time nor change of government has contributed so much to the destruction of the hundreds of magnificent cities which once covered this country, as the desolating influence of the earthquake, and many are the cities that now exist, which have been prostrated over and over again, and rebuilt, each time in diminished splendor, until at last they are little better than collections of huts when contrasted with their original condition. All the country at the present day seems to be as much subject to them as formerly.

The only part of Western Asia Minor where phenomena are seen strictly analogous to those of active volcanoes, is in the *Catacecaumene* or burnt district, situated in Lydia, about one hundred miles east of Smyrna. Numbers of volcanic cones exist in the neighborhood of *Koola*, of many of which the craters are quite distinct, especially the one called *Kaplar Alan*, which has a perfect crater about half a mile in circumference, and two or three hundred feet deep. The extent of this region is some twenty miles long by eight broad. We have no record of any activity in these volcanoes, and Strabo described them in his day quite as they are now, and the Turks give to Satan the full credit of having created such a black parched-up district. My object at the present time is merely to mention this district, as a full description of it enters into a paper on the earthquakes and volcanoes of Asia Minor, that I propose publishing at some future time; it is brought forward now merely to show what this volcanic centre has to do with the thermal springs just described.

Remarks on the occurrence of Nitrogen in Thermal Waters.—The only substance connected with these waters that I shall allude to, is the nitrogen contained in the gas accompanying many of them, and in some instances constituting almost the entire gaseous product, as in the case of the springs of Yalova. This singular fact attracted my attention several years ago, while

examining into the gaseous products of various springs, and I then ascertained that the gas was found especially with warm springs; the nitrogen, when found accompanied with oxygen, existed in proportions much greater than in the atmosphere, and in numerous instances it was almost pure. The question naturally arises, whence comes this nitrogen? and as we know of no other natural source of nitrogen than the atmosphere, it occurs to the mind that there is a source of the gas in the thermal waters, which, before they pass to the heated substrata, absorb a certain amount of air; the oxygen of the air contained in the water combines with the rocks and minerals, or is taken up by some de-oxydizing agent in the waters, which, as they return to the surface naturally bring the nitrogen of the air freed of all or most of its oxygen.

This explanation, which appears so natural, does not, however, account for the fact, and I have been obliged to abandon it. Did the nitrogen in these waters occur in such small quantities, as we might suppose to have been absorbed by water, the explanation would hold good; but the fact in the case of the springs at Yalova and many other sources, is, that the gas, which is nearly pure, bubbles up in *great abundance*. Again, if the nitrogen evolved by springs be simply such as the water absorbs before penetrating the surface of the earth, how does it happen that this gas escapes from springs of ordinary temperature? For it is reasonable to suppose that the water having once taken into solution a gas, will not give it out except by heat or the presence of a large amount of saline matter, neither of which occur to explain the evolution of nitrogen gas from certain springs.

Feeling thus satisfied that the nitrogen in the gaseous products of springs is not owing to its absorption from the atmosphere, its origin has been sought for elsewhere, but without success, and I am constrained to believe that nitrogen is one of those elements stored up in the interior of the earth, in more or less abundance, either pure or combined, and frequently finds its way to the surface through those fissures by which mineral waters are conducted. Its more frequent occurrence with thermal waters is doubtless owing to the greater depth from which the latter come.

After all, however, that has been said, we must acknowledge the explanation imperfect, and as only furnishing another evidence of the difficulty of learning anything of the origin or uses of this singular substance, nitrogen in its elementary state.

On the Analysis of these waters, particularly with reference to the Silica and Alkalies.

The general method of analysis adopted, differed but little from that usually employed; and the construction of the salts out of the acids and bases has been made entirely from the dictates of my judgment in the matter.

The examination of the silica attracted considerable attention, from the fact that we are in the habit of always estimating it as uncombined silica, even when found in alkaline waters. Although my researches are sufficient to prove to my mind the inaccuracy of this, still I have not thought proper in this paper to deviate from the rule generally adopted, leaving it to more extended research to decide the point.

In the analysis of the waters of Broosa, nearly all of which are alkaline, the following fact has been observed; that on concentrating a considerable quantity of the water to a small bulk, all the carbonate of lime is precipitated and a portion of the silica (whether in combination with lime or not is not yet decided); but a large portion of the same still remains in solution, as well as some lime, although the water is alkaline with an excess of carbonate of soda. The silica is in such quantity that it could remain only in solution in combination with an alkali, in fact there is a silicate of soda and lime present.

The question here arises whether the silica was in a state of combination before the water was concentrated, or is it a result that has taken place during the evaporation; this question can only be decided by more extended investigation.

The observation of the above fact has led me to adopt the following method of estimating the silica in mineral waters. Take a certain quantity of the water, evaporate almost to dryness, add hydrochloric acid, a little more than is required to saturate the carbonates present; continue to evaporate to complete dryness, and then add water acidulated with a little hydrochloric acid, filter and wash the silica that remans on the filter; in this way we are sure to have the silica perfectly free from any silicate.

The method adopted for estimating the alkalies will be mentioned in a few words, as more details of it will be given in a paper devoted especially to that subject, the method has particular reference to the separation of the alkalies from magnesia.

Take the solution filtered from the silica, evaporate to dryness to drive off the excess of acid, add a little water to redissolve, then add pure lime water and filter, when the chlorids of the alkaline metals and calcium with excess of lime will pass through, the magnesia, alumina, oxyd of iron, &c., remaining on the filter. Separate the lime with carbonate of ammonia, or still better with oxalate of ammonia, evaporate to dryness, and heat to drive off the ammoniacal salts, when nothing but the chlorids of alkaline metals will be left which can be separated in the ordinary way.

This completes the description of all the thermal waters of Asia Minor which have as yet come under my notice, with the observations that the investigation have given rise to.

ART. XXXIX.—*On the Preservation of Animal Substances;* by HENRY GOADBY, M.D., F.L.S., formerly Dissector of Minute Anatomy to the Royal College of Surgeons of England.

In the preserving fluids that I use, and which are known by my name, the following ingredients occur, viz.: rock salt, alum, corrosive sublimate, and the white oxyd of arsenic, or arsenious acid.

These materials are never all employed at one time, and they should be used judiciously, to prevent the contingency of *destroying*, rather than *preserving* specimens of Natural History.

To this end, I think it desirable to describe the *properties* of the materials respectively before giving the necessary formulæ for the fluids.

Rock (or bay) salt is very preservative, and will maintain the characteristics of all tissues unimpaired, better than any other agent with which I am acquainted, provided the *strength* be well regulated; and I make much greater use of the purely saline, or B fluid, than of any other.

Alum possesses very important conservative properties; it is *astringent*, coagulates albumen to some extent, rendering transparent tissues opake in proportion to the volume of alum brought in contact with them; but it *destroys the carbonate of lime*, converting it into the insoluble sulphate. The aluminous, or A, 2, fluid, however, is a very valuable composition; and to it I owe many important preparations, which may be found both in my own possession, and in the Hunterian Museum of the Royal College of Surgeons, of England, and which could never have been made without its assistance.

Alum *combines* with animal tissues so perfectly, that it cannot be dissolved out of them by long continued maceration in water. Whenever it is considered necessary to use the aluminous fluids either to give form, and support, to an animal, or any part of an animal, or a delicate tissue, by reason of its astringent property, or to render diaphanous animals or tissues opake enough to be visible, *the excess of alum* should be washed away with water, and the animal or whatever it be, with few exceptions, removed from the aluminous, and preserved permanently in the B fluid. It should be borne constantly in mind that the effect of fresh volumes of the aluminous fluid should be cautiously watched, lest the alum produce mischievous results; but with care, it may even be used to the full extent of its valuable properties on the soft parts of an animal enclosed in a shell of carbonate of lime, or otherwise possessing that earth, for the muscular, nervous, and other soft tissues, will be much sooner affected by the action of the alum than the denser tissues containing earthy matter. It

will hence be seen that the aluminous fluid is not of universal application.

Corrosive sublimate is also astringent, and the coagulator of albumen; the intention of its application is not for the sake of either of these properties, but simply to prevent vegetation *growing in the fluids* respectively. But inasmuch as albumen takes from corrosive sublimate a portion of its chlorine, and thus converts it into calomel, and as all animal tissues are more or less albuminous, the propriety of using it at all, may well be questioned. In places where the sporules of fungi abound, as in the store-rooms of large museums, not even the presence of corrosive sublimate can prevent them from *growing upon the surface* of *either* of my preserving fluids, if they contain animal matter of any kind and are in *open* vessels, i. e., not hermetically sealed; but, in a long experience of this fact, I am bound to say that, although I have had open jars, dishes, and other vessels containing dissections of animals waiting their turn to be mounted permanently as preparations, in which the surface of the fluid has been covered during the summer months with vegetation of considerable substance, and which has continued to increase, and flourish magnificently for weeks, yet, I have never known it to *descend* into the fluid, or affect the dissections (provided they were well covered with fluid) in any way. Indeed, either of these fluids will preserve plants, as easily, and certainly, as they preserve animals; and were the fungus to grow *into* the fluid, it would die, and be preserved. Neither have I at any time, during fourteen years experience of preparations made by the use of my fluids, and contained, and sealed down, in the several forms of vessels and cells, also of my invention, ever found a particle of vegetation in a single preparation; and during the last six years I have been using the fluids, both for permanent preparations, and stores, without the addition of corrosive sublimate, and always with satisfactory results. I believe, therefore, that the corrosive sublimate may be safely left out, although I shall include it in the recipes of the fluids.

As arsenic acts upon glass and glass vessels, by combining with the lead, and for other reasons, it cannot be employed for preparations that are desired to be permanent. I have made a few such attempts, but they have all ended in failure. Arsenic possesses the power of softening animal tissues to a most remarkable extent, and this property has no limit.

A few years ago I was desired by the examiners in Anatomy, of the University of London, to preserve a body during the summer season for their examinations in the autumn. Desiring to retain the tissues severally in as natural a state as possible, I added arsenic to the B fluid. For some months, nothing could exceed the success of this experiment, and if I had changed the

fluid, and substituted B fluid without arsenic, I believe the body would have been permanently preserved. It was neglected, however, in this respect, although I watched it with some solicitude until, after the lapse of rather more than twelve months, I found the entire body (with the exception of the bones) reduced to the condition and appearance of decomposing size, except that it remained perfectly sweet. I have made a number of experiments, with the like results. I have seen the characters of muscle, tendon, nerve, &c., gradually disappearing, until nothing but a glairy fluid remained, but which was always *perfectly sweet.*

The softening property is that for which I employ arsenic; either to recover animals that have been hardened, and corrugated in alcohol, or to enable me to proceed with elaborate dissections of nerves, which must necessarily be tedious. My friend Dr. T. S. Beck of London could never have made such a display of the nerves of the uterus—the finest dissection of nerves in the human subject that I believe has ever been made—without the aid of arsenic, which was never allowed to do mischief, occasionally washed away, then renewed, and so on; and the nerves, under its well regulated influence were as tough as copper wire, and although very delicate in appearance, would bear pulling and stretching with impunity.

The aluminous fluids I originally designated by the letter A, and I called them 1 or 2 as the same weight of the ingredients were dissolved, either in one quart of water or two quarts; they are thus made.

A, 2

Rock salt,	4 ounces.
Alum,	2 ounces.
Corrosive sublimate,	4 grains.
Boiling water,	2 quarts.*

The A1 only differs from the above in having half the quantity of corrosive sublimate, and water. It is very rarely used, being generally too astringent.

B

Rock salt,	8 ounces.
Corrosive sublimate,	2 grains.
Boiling water,	1 quart.

The corrosive sublimate must never exceed, under any circumstances two grains per quart of water; otherwise there will be in time a white precipitate on the preparation that cannot be removed, and which will greatly disfigure it.

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* The *imperial quart* of 40 ounces is intended to be understood throughout this paper.

When the B fluid is made according to the above recipe, its specific gravity at a temperature of 60° will be 1·100, and with it, terrestrial and fresh-water animals can be well preserved.

For marine animals the strength of the fluid must be increased by the addition of salt to 1·148, otherwise they will be decomposed. A great number of marine animals in the first stages of the preserving process require alum, but it must be cautiously used, and carefully watched, and as soon as it has done all that is required of it, the animal should be well washed in clean water and placed in the B fluid. There is no objection to frequent contact with alum, if necessary, provided the process be conducted on the principle here laid down.

The Arsenical Fluid.—When I employ arsenic for its *softening* properties, I use it alone, unless the process is likely to occupy much time, and in that case, I combine it with the B fluid, in the following proportions, and call it C: B fluid, as directed above, arsenic 20 grains. Arsenic can no more be trusted with carbonate of lime, than alum; and if it be desirable to employ it on any molluscous animal the creature should be removed from its shell prior to its introduction to arsenic. The solutions of arsenic that I have employed differ in strength from 20 grains to 60 grains to a pint of water, (imperial measure, 20 ounces) or to the pint of B fluid. It is not easy to dissolve this mineral, and the only plan which I have found successful, is to place the quantity of arsenic to be dissolved in a Florence oil flask with half a pint of water, apply a spirit lamp, and boil till the whole be dissolved, it can then be diluted by the addition, either of more water, or preserving fluid. I may mention one singular fact of preservation by this fluid, no less of the animal, than (which is most important) its color.

Upwards of six years ago my son collected for me several specimens of the larvæ of Cossus ligniperda, the peculiar color of which had never been preserved. In alcoholic fluid, of any strength, it turns quite black, which is a common result of the application of spirit for preserving caterpillars; in addition, most insect colors are soluble in alcohol.

The specimens included larvæ of the first and second year, and one fine sample of a three-year larva about to change to a chrysalis. Of the former specimens I preserved some in the A 2, and the rest in the B fluid, and placed the last in a solution of arsenic. The aluminous fluid has hardened and disfigured the caterpillars nearly as much as spirit would have done; they are softer, and in a better state for dissecting, in the B fluid; but they have lost all their rosy redness of color in both fluids, and are partially black.

It was reserved for the arsenic to give me one caterpillar so beautifully preserved that all its characteristic color, even to the

delicate tint, is maintained to this time. I *believe* that the interior has not been destroyed by the softening tendency of arsenic before alluded to, because, if so, I think there would be considerable deposit in the fluid, which has not occurred; neither in that case would the insect retain its roundness, and fullness, but on the contrary become flaccid by the removal of those tissues (muscles) that give form to the integument. As this caterpillar had been secluded from the operation of light (the fruitful agent for destroying color in animals) for more than twelve months, I determined to try the effect of constant exposure, to which I submitted it for three years in England, and for six months in this country; its beauty is still unimpaired. As it is a sole specimen, and I am not likely to obtain another, I am unwilling to dissect it.

I have been particular in speaking of the successful application of arsenic in the preservation of *color* in this caterpillar, because I believe it is of some importance. It is most interesting to collect the larvæ of Lepidopterous and other insects, as far as possible, but they lose much value for the purpose of instruction and for collections, unless their color can be permanently preserved; and I have great hopes that the fluid which has proved so eminently successful in the instance of the caterpillar of the goat-moth, which takes on the described blackness a very few days after death, in every other preserving fluid, may be equally efficacious in the preservation of color, in the other species.

Mode of using the Preserving Fluids.—A knowledge of the proper methods of using the fluids is essential to success, for in other hands than my own, they have led to the destruction rather than the preservation of specimens. Men have constantly treated my preserving fluids as though they were using spirit, entirely overlooking one very important consideration, namely, the vast difference between their specific gravity and that of alcohol. In the latter, we have a fluid so light that every animal is *heavier*, and will instantly sink in it; the conditions are exactly reversed in the former case, where every animal, from an animalcule to an elephant, is lighter, and will float upon either of them.

Neither of my fluids (always excepting the arsenical) *can be employed of full strength in the first instance*, and any thing to be preserved in them should undergo previous maceration in clean water, to which, after a time, preserving fluid may be added until the animal rises to the surface. The fluid and the water must be intimately mixed mechanically, or the water will rise through the denser fluid, and retain its integrity for a long time.

The animal will insensibly absorb, and become saturated with, the *ingredients* of the preserving fluid, but in a state of considerable dilution; the strength of the fluid must now be gradually in-

creased, and intimately mixed, until the animal again rise, and in time it will become saturated with this denser fluid. In many instances it is advisable to keep the animal forcibly at the bottom of the vessel in which it is being preserved *by weights*, and this is particularly necessary in hot weather when the preserving process should be expedited with all the speed that is consistent with safety. It is easy to ascertain if the animal be saturated with the fluid by removing the weights, and in that case, to go on increasing the strength of the fluid: in fine, success depends on carrying out the laws of endosmose, and exosmose. The diluted fluid used in the first stages should be thrown away, and frequently renewed, as, being replete with animal fluids, it contains within itself the elements of decomposition, and increases the difculty of obtaining ultimate success. This remark, however, applies less to the aluminous, than to the B fluid, as in the former, the coloring matter, and animal deposits of all kinds so abundantly seen when spirit is used and which occasions the steady and constant discoloration of that fluid, for, in some cases, many years, and which so generally tends to the disfigurement of preparations in museums is altogether *insoluble* from the instant it, or they, come in contact with alum; and for this very important reason alum may be almost *always* used in the early stage of preservation, the former cautions on this subject being strictly attended to. Preservation of animals by means of these fluids, then, can only be accomplished by the daily addition of fluid until the creature be saturated with the fluid of the full strength indicated. Nor should the solicitude of the operator end immediately at this point, as it will be necessary occasionally to renew the fluid and often to test its strength. To shorten this species of labor I long ago procured a glass jar, or tube, two and a half inches long, and three-fourths of an inch wide, with a flat bottom, to be used as a proof glass; I then adjusted some specific gravity bubbles so accurately that they *rise very slowly* in the fluid, the precise strength of which they are intended to indicate; if the fluid be weaker than exact strength, they fall to the bottom, and there remain; if stronger, they quickly rise. They are marked on the top A 1, A2, B, S, the latter indicating a *saturated* solution of rock salt with which it is convenient to increase the daily strength of the B fluid in the manner already described.

By pouring a little fluid into the small proof glass, and applying a bubble as the test of strength of the fluid that has been employed, the operator will instantly learn, not the exact strength, (which is unnecessary,) but that the fluid is either of *the* strength, or weaker or stronger;—all the information he needs to guide him in his labors.

Instead of the bubble marked "B" I would substitute two, one indicating 1·100, the other 1·148, and the Italian barometer

makers could easily graduate such bubbles. The whole apparatus is enclosed in a japanned tin box 1 inch deep, 1½ wide and 2⅞ths long, which can be carried in the waistcoat pocket, and costs but little.

When either of the foregoing fluids are required for the display of preparations in a public or private collection, they should be *well filtered*, and for this purpose they may be passed a great number of times through fine flannel rammed into the nozzle of a large earthen funnel, or once through a filtering machine, or twice or thrice through good filter paper. If the filtration be properly performed, these fluids are remarkably bright, white, and brilliant, far exceeding in this respect any alcoholic fluids. Rough filtration may be satisfactorily effected by once passing through the thick flannel used for a jelly bag; but if this be not at hand, it is only necessary to allow the fluids to stand quietly in the vessel in which they were made until quite cold, and then carefully pouring off the top, the extraneous matter always found in rock salt will gravitate, especially in the aluminous fluid, which has the property of throwing down any thing which disturbs the transparency of water. Neither of my fluids can be retained in open vessels, glass jars, or even stoppered bottles, for any length of time, without additional protection.

In *open* vessels, the water evaporates, and the salt crystallizes, to the total destruction of the specimens included. Salt, being highly deliquescent, the volume exposed to atmospheric influence (the upper portion) becomes greatly diluted when the atmosphere contains moisture and ascends into the neck of a bottle, even around a well ground stopper, by capillary attraction; it gains the upper surface of the stopper and then descends the sides of the bottle, and will lie as a pool on the shelf on which the bottle rests.

As the weather changes, and becomes dry, the salt crystallizes, and thus forms a conduit for the fluid the next rainy day, by which it can greatly, and readily, extend its outposts; and by this means, in time, it will pass completely out of the bottle or other vessel. Bladder will not confine it, applied to a glass jar on the plan employed for spirit preparations; and the only plan is to cover the jar with a plate of *flat* glass (patent British plate manufactured by Messrs. Chance of Birmingham, is the best) and seal it down with the patent marine glue, applied to the glass, with a hot iron.

The best, neatest, and readiest mode, in my experience is the plan of my invention, namely: first place in the upper vessel of a small copper glue pot some marine glue cut small; in the lower vessel, where the carpenter would put water for the careful dissolution of animal glue, put linseed oil, and then apply heat; the temperature of the boiling oil will dissolve the glue the first, second, and even a third time, with care; after this it becomes altered in its properties, and refractory.

The dissolved glue should be rapidly applied to the rim of the glass jar (which must be quite dry and free from grease,) with a brush, and the only brush that will stand, I make in this way. I take a piece of rattan cane as long as a cedar drawing pencil, and cut off the cortex carefully from one end of it to the length I desire the brush to be, being particular not to let the knife go into the substance of the cane any more than I can help. I macerate the prepared end of the cane for a short time in water, and then, while yet wet, I pound it with a hammer upon some hard substance (iron or stone) constantly turning it with my hand until all the fibres of the cane be liberated, and my brush is then complete. I still use a brush of this kind which I have employed for several years extensively, and none other will stand twice using, the hairs come out with the glue, and are in the way of a good joint. A disc of glass should be cut to fit the top of the jar, made clean, and the part that is to be in contact with the jar also thinly coated with the hot glue. The disc should previously have had a small hole drilled through the centre, (about one-eighth of an inch diameter) for a reason that will presently appear.

The two surfaces of glass being *apparently* coated with marine glue, but *really without contact*, the latter must be insured by means of a hot iron which should be carefully passed over the surface of the glue several times till it and the glass become hot, care being taken to keep the iron constantly in motion, and always on the edge of the jar, or of the disc, as in that case the expansion will be equal, and no danger occur even if the iron be *red hot;* but, it will instantly break if the iron be allowed to linger in one place, or touch any but the outer portion of the disc, or the rim of the jar.

The jar should be thus prepared while *empty, and dry;* and when complete, the fluid may be poured in, to about one-half the height of the jar, together with the preparation to be suspended in it. The strings necessary for this purpose may be brought over the edge of the jar, and pressed into the glue on the surface, if soft enough to admit of it; the preparation may now be regulated to the required height in the jar, and the threads of suspension kept in their place by a wet string passed round them on the outside of the jar, several times. If any fluid chance to be on the surface of the marine glue on the rim of the jar, it should be removed; and when dry, the prepared surface of the disc should be placed on the jar and the two brought together in intimate contact by the hot iron, which, as in the former case, must be constantly passed round on the edge, and the disc simultaneously pressed down, until the process be completed. The extraneous glue on the outer edge may be made smooth and neat, by the hot iron.

By means of a syringe, to which a small pipe is affixed, fill up the jar with the preserving fluid, not quite full, however, as the

great expansion of the fluid (the B especially) in sudden increase of temperature, may cause the breakage of the top glass; then cut a cork to fit the small hole tightly, insert it, pare it off level with the surface, place upon it a piece of solid marine glue made to adhere to the cork by means of the point of the hot iron, and cover it with another disc of glass of about the size of a ten cent piece, and the preparation is finished.

It is a good practice to prepare the portion of thread that is to come outside of the jar, the cork, and even the surfaces of glass to be coated, with a liquid solution of the marine glue, which may be made by dissolving a piece of glue in an excess of white-wood Naphtha.

Should a stopper become fixed in the neck of a bottle by the crystallization of the salt, it may be easily removed by dissolving the salt by water, and gently tapping the cross piece of the stopper at its extreme ends, (*never across its shortest diameter*,) with a door key. If the cross piece come off, make it, and the remainder of the stopper that is in the neck of the bottle *hot* with the iron, apply marine glue, and cement them together,—when cold, renew your operations,—the stopper is stronger now than before, will easily come out, and last longer than one not broken. To keep the fluids in stoppered bottles and to prevent the possibility of the salt crystallizing on the outside of the stopper, the marine glue may be advantageously employed; or a cement, proposed by Prof. Olmsted, of Yale College, and made by melting resin and lard together by the application of heat, and intimately mixing them. The respective quantities of the materials will depend on whether the cement is required to become hard, or not. If the former, the resin must be in excess; if the latter, use more lard. For the purpose that I indicate above, it should be *stiff*, and *ropy;* remaining just soft enough in hot weather, to spread with a palette knife.

As a final remark I would say, that the preservation of animals, either in alcoholic, or my fluids, is greatly facilitated by employing, in the first stages of the process, a large volume of fluid.

Crowding animals together in a limited space, and with only a small quantity of fluid, is a fruitful source of injury and loss of the majority, if not of all the specimens; when, however, the preservation is completely effected, the specimens may be packed very closely together, in a small vessel, and as much fluid of required strength as will occupy the interstices is amply sufficient for transportation, or stores, and will last for years, especially if the fluid be kept in, by running some marine glue round the stopper and neck of the bottle with a hot iron, or by using the resinous cement.

In another paper I propose to treat of the modes of making preparations.

Art. XL.—*Mineralogical Notices.* No. III.

(Concluded from page 222.)

Orangite.—Dr. C. Bergemann of Bonn, (Pogg. Ann., lxxxii, 561,) thus describes the mineral Orangite which contains the metal, Donarium. Color yellowish-red, passing either to brown or yellow; powder or streak light orange. In thin splinters transparent, and in larger pieces translucent. Structure foliated in one direction; cross fracture flat conchoidal. Hardness between fluor spar and apatite, or 4·5; specific gravity 5·397, Bergemann, 5·34, Breithaupt. Small splinters heated in a platinum spoon become dull-brown, and on cooling again of an orange color, and the larger pieces lose their translucency. In a glass tube gives off moisture. Held with the platinum forceps in the flame of a spirit lamp, there is slight decrepitation. B.B. on charcoal infusible, the edges only being slightly glazed and perhaps only from a mixture with foreign matters. Mixed with soda the silica is dissolved, and the rest remains in the glass rendering it opaque. With borax a yellowish pearl, becoming colorless on cooling; with salt of phosphorus in the outer flame, a reddish glass, in the inner, yellowish, and in either case colorless on cooling. With acids easily decomposed yielding with muriatic acid a perfectly clear jelly, of a yellow color, and it is even attacked by dilute acid. Digested for twenty-four hours with a solution of an alkaline carbonate of ordinary concentration, it is strongly acted upon.

This mineral is from Langesundfiord near Brevig in Norway, where it occurs in zircon syenite, with wöhlerite, mosandrite, thorite, zircon, hornblende, black mica. Its composition is given on page 280 of this volume.

Loganite, a new mineral; Mr. T. S. Hunt, (Phil. Mag. [4], ii, 65, July, 1851.)—Loganite occurs at Calumet Island on the Ottawa in white crystalline limestone, mixed with green serpentine, phlogopite, pyrites and rarely crystals of apatite. The form appears to be a prism, with the acute and obtuse lateral edges replaced and also the acute solid angles. Crystals small; edges generally rounded, and faces faintly shining, with the lustre vitreous or vitreo-resinous. Cleavage parallel to the sides and base of the prism distinct, macrodiagonal perfect. Color clove brown to chocolate brown; streak and powder grayish-white. Subtranslucent. Brittle, fracture uneven. Heated in a tube yields water freely with an empyreumatic odor. B.B. loses color, becoming grayish-white, but infusible; with cobalt solution becomes blue. With acids partly dissolved. Composition,

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$	$\dot{H}$ & $\dot{C}$	$\dot{C}a$
1.	32·84	13·37	2·00	35·12	17·02	0·96=101·31
2.	32·14	13·00	2·28	36·43	16·83	0·93=101·61

In another trial, S̈i 33·17, and Ċ & Ḧ 16·50. Supposing the lime combined with the carbonic acid, it will leave [1], 16·36, [2], 16·12 of water. This affords the Berzelian formula,

$$4\dot{M}g^{6}\,\ddot{S}i + (\ddot{A}l, \dot{F}e)^{3}\,\ddot{S}i + 12\dot{H},$$

corresponding to silica 33·29, alumina 13·31, peroxyd of iron 1·92, magnesia 35·50, water 16·00 = 100·02. In the Gerhardtian notation, the formula according to Mr. Hunt is $Si\,O^{3}\,(Al\,\beta\frac{4}{3}\,Mg\frac{6}{3}\,H\frac{8}{3})$, the oxygen ratio for the silica and bases being 17·515 : 34·990. It approaches chlorite closely in composition, although not at all foliaceous. The species is named in honor of Mr. Logan, who is at the head of the Geological Commission of Canada.

Matlockite, a new Oxychlorid of Lead; by R. P. Greg, Jr., (Phil. Mag., [4], ii, 120, August, 1851.)—Matlockite occurs at the old mine of Cromford near Matlock, with corneous lead (phosgenite, *Haid.*) Form dimetric; occurs in tables which are generally thin and superimposed on each other, occasionally slightly curved. Cleavage basal, but not perfect. A single crystal in the hands of Mr. W. G. Lettsom is an inch square, an eighth of an inch thick and transparent. The edges and angles are replaced; P : e = 111° 50′; P : a = 119° 34′; e : e = 97° 58′ and 136° 19′; a : a = 104° 6′ and 120° 52′. Color yellowish, sometimes a little greenish. Lustre adamantine and occasionally pearly. G. = 7·21. H. = 2·5–3. Composition according to Dr. R. A. Smith:—

Chlorid of lead 55·177, oxyd of lead 44·300, moisture 0·072 = 99·549, giving the proportions of 1 of chlorid of lead to 1 of oxyd of lead = chlorid of lead 55·46, oxyd of lead 44·53 = 99·99.

The *corneous lead* of the same locality afforded Dr. Smith, Chlorid of lead 51·784, carbonate of lead 48·215 = 99·999.

Pyroxene and Hornblende.—Rammelsberg observes in his 4th supplement, p. 106, that certain augites, as a black augite of Taburg, analyzed by H. Rose, a brown from Pargas, by Nordenskiöld, a black from the basaltic tufa of the Azores, by Hochstetter, have the composition of hornblende; while some hornblendes, as a tremolite from Pennsylvania has the composition of pyroxene. The species have been long known to belong to the same system of crystallization, and to be mutually derivable, and in uralite, as shown by G. Rose, there is an example of a substance with the external form of augite and the cleavage structure of hornblende.

In volume lxxxiii of Poggendorff's Annalen, p. 458, (July, 1851,) Rammelsberg gives the results of analyses of an augite and a hornblende from the basaltic tufa of Härtlingen in Westerwald. He obtained—

	S̈i	Ä̈l	Ḟe	Ṁn	Ċa	Ṁg				
1. Augite,	47·52	8·13	13·02	0·40	18·25	12·76	= 100·08			
Oxygen,	24·69	3·79	2·89	0·09	5·19	5·10				
2. Hornblende,	42·52	11·00		16·59	12·25	13·45	Ṅa 1·71	K̇ 1·92	T̈i 1·01	= 100·45
Oxygen,	22·09	5·14		3·68	3·48	5·38	0·43	0·32		

The second is the mean of three analyses.

The augite gives for the oxygen of the silica, alumina and protoxyds, 24·69 : 3·79 : 13·27; and for the oxygen of the silica and alumina together 28·48. 28·48 : 13·27 = 1 : 2·15. The ratio does not become 1 : 2 except we suppose $2\dot{\mathrm{A}}\mathrm{l}$ to replace $1\ddot{\mathrm{S}}\mathrm{i}$.

The hornblende affords in like manner 22·09 : 5·14 : 13·29, and for the oxygen of the silica and alumina 27·23. 27·23 : 13·29 = 1 : 2·05.

The augite has nearly the ratio usually given for hornblende, 4 : 9; while the hornblende has the augite ratio 1 : 2. So the Taberg black augite affords the hornblende ratio 1 : 2·39 = 4 : 9·5. Rammelsberg hence shows that hornblende does not consist uniformly of $1\dot{\mathrm{R}}\ddot{\mathrm{S}}\mathrm{i}$ with $1\dot{\mathrm{R}}^3\ddot{\mathrm{S}}\mathrm{i}^2$, the usual formula; but that both it and augite may be a pure bisilicate, $\dot{\mathrm{R}}^3\ddot{\mathrm{S}}\mathrm{i}^2$, or may correspond to the general formula, $m\,\dot{\mathrm{R}}\ddot{\mathrm{S}}\mathrm{i} + n\,\dot{\mathrm{R}}^3\ddot{\mathrm{S}}\mathrm{i}^2$, in which m and n may be each a unit, or 3 and 2, or other numbers, the addition of m atoms of the trisilicate to n atoms of the bisilicate, producing no change of form. The ratio 4 : 9·33 which is common in hornblende, would give for m, n, the values 3, 2, and afford the formula $3\dot{\mathrm{R}}\ddot{\mathrm{S}}\mathrm{i} + 2\dot{\mathrm{R}}^3\ddot{\mathrm{S}}\mathrm{i}^2$, equivalent to $\dot{\mathrm{R}}^9\ddot{\mathrm{S}}\mathrm{i}^7$. This formula corresponds to the analyses of a tremolite from Fahlun, an actinolite from Taberg, a hornblende from Helsingfors, each containing no alumina; and of the aluminous varieties from Kongsberg, Kimito, La Prese, Lindbo, Vogelsberg, Bohemia, the Uralite, &c.

M. F. Sandberger (on p. 453 of the lxxxiii volume of Poggendorff,) precedes the paper by Rammelsberg by mentioning many cases of the close intermixture of hornblende and augite crystals, and describes cases of twins in which one part of the crystal is augite and the other hornblende. He also describes crystals of augite containing throughout particles of chrysolite, the latter mineral being in parallel combination with the former. In other specimens he finds hornblende and chabasite intimately mingled. This combination of hornblende and augite in a single twin would seem to show that the difference between them is not due to temperature. M. Sandberger urges that the hornblende and augite in the cases adduced cannot be either one or the other a result of pseudomorphism, and that both are properly the same mineral species.

Rutile of Waterbury, Vermont.—Dr. A. A. Hayes in remarking on a specimen of quartz containing acicular rutile from Waterbury, Vermont, before the Boston Society of Natural History, (Proceedings, 1851, 23,) stated that the acicular crystals must have existed occupying a cavity before the quartz was formed. The rutile needles often pass through the regular terminations of the quartz crystals, and roughen the surfaces by their broken ends. The flaws or rents in the mass of the crystal are most frequent about the rutile, indicating that this mineral by its

changes of temperature, as it does not expand at the same rate as quartz, may cause the destruction of crystals of the latter.

Beudantite of Levy.—Mr. H. J. Brooke states (Phil. Mag., [4], ii, 21, July, 1851,) that on showing a crystal of the Beudantite of Levy to M. Descloiseaux, he acknowledged that it differed entirely from the mineral examined by himself and M. Damour as Beudantite, as well as every other specimen under that name which he had seen.

Emerylite on the Diaspore of Katharinenberg.—Mr. Thomas F. Seal of Philadelphia states in a letter to one of the editors of this Journal that he has just received a specimen of the diaspore of Katherinenberg and finds it also quite a good specimen of *emerylite.*

Agalmatolite.—This material is called *Fun Shih* or Powder stone by the Chinese, from its softness. It is often reduced to powder and used in this state in making razor strops. It is found in the Canton province. The reddish colored variety is more common than the green.—*Correspond. of S. W. Williams of Canton.*

Karstenite.—The crystallization of Karstenite has been studied by J. F. L. Hausmann, who points out its close conformity in its angles with heavy spar and celestine, and makes some general remarks on isomorphism or homœomorphism.—*Soc. Sci. Göttingen, March* 15, 1850.

Cinnabar.—A large deposit of cinnabar, yielding 80 p. c. on analysis has been discovered in the island of Corsica.—*J. de. Pharm., March*, 1851.

Gold from California, (Phil. Mag., [4], i, 261.)—Analyses of three samples, after separating the oxyd of iron mixed with it.

I.	Gold	93·53	Silver	6.47 = 100.	A. D. Thomas.
II.	"	93·06	"	6·94 = 100.	F. Walters.
III.	"	96·42	"	3·58 = 100.	A. D. Thomas.

Gold of New Grenada.—The principal deposits of alluvial gold in New Grenada, are those of Sinitabé, Oquendo, Baharona, San Juan, La Vaca and Rio Dulze. The best mines are twenty-five or more in number, of which those of El Zancudo, Titiribe, La Clara, Amalfi and Pedrero are worked. The amount exported and made into coin for the year ending with August 31, 1848, was 5·187 liv.—(Ann. des Mines, [4], xviii, 358.)

On the origin of Ores of zinc, lead, iron and manganese in irregular beds; by M. J. Delanoue.—Ann. des Mines, [4], xviii, 455.

On the Sulphur bed of Szwoszowice, near Cracow; by M. L. Zeuschner.—(Ann. des Mines, [4], xviii, 125.)

On the Nepheline rock of the Löbau mountain; by Dr. HEIDEPRIEM, (J. f. pr. Chem., l, 500.)—This author finds the mass of the rock to consist of 45·38 p. c. of augite, 32·61 nepheline, 4·00 magnetic iron, 3·91 apatite, 3·42 water, 1·33 titanite, the remaining 9·35 p. c. being in part olivine. The augite, a diopside, consists of

$\ddot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	
52·54	0·42	25·42	17·54	2·29	*trace*	= 98·21

The nepheline from selected grains, afforded—

$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
43·50	32·33	1·42	3·55	0·11	14·13	5·03	0·32	= 100·39

Analyses of the whole stone gave

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{P}$	$\dot{H}$
I.	41·13	14·33	6·61	12·23	7·20	0·06	5·33	4·38	1·70	1.65	3·42
II.	42·12	14·35	23·12	13·00	—	0·18	6·14	4·11	2·18	1·65	3·42

with chlorid of calcium 0·04, fluorid of calcium 0·27, in each, and in the 2nd, 0·54 of titanic acid.

Variolites of Drac.—Analyses and descriptions are given by M. Gueymard in the Ann. des Mines, [4], xviii, 41.

On the structure and composition of certain rocks of the Alps and Dauphiny; by M. LORY, (Bull. Soc. Geol. de France, vii, [2], 540.)—This paper treats mainly of the hornblendic rocks, diabase and diorite. The diabase of the Chalanches in Allemont (Oisans) consists principally of hornblende of a deep green color, lustrous and largely lamellar; in some parts, the large crystals of hornblende are so filled in with smaller, that there is little room left for feldspar; in others, the feldspar is more abundant, and mixed in with the hornblende like a graphic granite. The hornblende consisted of—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	alkalies (diff.)	
Hornblende,	45·3	8·0	25·7	12·3	6·0	1·3	ign. 1·4 = 100
Oxygen	21·5	3·7	5·8	3·5	2·2		

The alumina appears to replace silica.

The feldspar afforded on analysis (p. 542)—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
Andesite,	59·4	24·2	0·6	3·7	*trace*	7·0	3·4	1·48	= 99·78
Oxygen	30·86	11·31	0·19	1·04		1·80	0·57	1·32	

It is hence andesite having the oxygen ratio for the protoxyds, peroxyds and silica 1 : 3 : 8. The andesite is associated with epidote, which is often abundant. This mineral gave on analysis (p. 543)—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$
Epidote,	40·6	30·2	11·2	17·7
Oxygen	21·1	14·1	2·5	4·9

Another diabase contains crystallized prehnite in prisms. Its hornblende afforded a different composition from the above, as follows:

	Si	Al	Fe	Mn	Ca	Mg	H
Hornblende,	50·9	4·9	21·2	*trace*	11·2	8·7	1·6, alkalies and loss 1·5

The feldspar of the rock is andesite as before, giving:—

	Si	Al	Fe	Ca	Mg	Na	K	H
Andesite,	59·9	25·1	*trace*	3·7	0·7	7·4	1·2	1·7 = 99·7

A *schistoid diorite* is a common rock in L'Oisans. There is also a *granitoid diorite*, consisting largely of whitish feldspar with disseminated hornblende crystals of a deep black color. The feldspar is *andesite*. This same feldspar is also found in the euphotide of Lavaldens in the department of L'Isère. This rock consists of deep olive green lamellar diallage and the white andesite; the latter afforded on analysis—

Si	Al	Fe	Ca	Mg	alkalies (diff.)	H
60·0	23·8	1·1	6·0	1·5	5·3	2·3 = 100

[A doubt existed among some members of the Geological Society with regard to the feldspar in the above analyses being andesite, on the ground that the rocks in which it has been reported to be found may contain some free silica; but this Delesse denies.]

Lava.—Rammelsberg makes the lava of Thjorsá, Iceland, from the analysis by Genth (given in this Journal, vol. vii, 2nd series, p. 114,) to consist of anorthite 55·59, augite 40·46, olivine 4·51. The Thiorsauite of Genth is impure anorthite according to this chemist.

For the lava of Háls, Iceland, which has a grayish black color and sp. gr. 2·919, he gives the composition, lime-oligoclase 63, augite 28, olivine 9. That of Efrahvolshraun, which is uncrystalline, with a black color inclining to gray and sp. gr. 2·776, consists, according to him, of 71·37 of lime oligoclase and 29·66 augite (including olivine and magnetic iron).

The lava of Etna was determined by Abich some years since, to be composed of 54·80 labradorite, 34·16 augite, 7·98 olivine, and 3·06 magnetic iron = 100. That of Stromboli, according to the same author, consists of 48·18 labradorite, 44·91 augite, 6·91 magnetic iron, or 44·30 labradorite, 39·12 augite, and 16·58 olivine. That of Vesuvius, of 60·19 leucite, 20·44 augite, 10·42 olivine, 8·95 magnetic iron = 100.

Rammelsberg also observes that the *Juvenas meteoric stone* has the same composition as the Thjorsá lava of Hecla, it consisting of anorthite and augite in nearly the same proportions.

Red Antique Porphyry.—Delesse has examined this rock with important results, (Bull. Soc. Geol. de France, vii, 524, 1850.) The feldspar is in small oblong macled triclinic crystals, of a whitish or rose color, rarely greenish. G = 2·690. Composition:—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	ign.
	58·92	22·49	0·75	0·60	5·53	1·87	6·93	0·93	1·64 = 99·67
Oxygen	30·61	10·51	0·23	0·13	1·55	0·72	1·77	0·16	

This result approaches both the andesite of Alsace and the lime-oligoclase of Forchhammer. The paste of the same rock gave—

$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	ign.
62·17	14·71	7·79	3·30	5·00	4·10	2·04	0·58 = 99·69

It is remarkable that the part driven off by heat is much less than with the crystals. Its density is 2·763, which after fusion is reduced to 2·486.

Red Syenite of Egypt.—This syenite, according to Delesse, consists of quartz, orthoclase, oligoclase, mica and often hornblende. Mean density 2·63. The orthoclase is of a reddish color. The feldspar which is commonly referred to oligoclase is usually white, sometimes yellowish or even greenish. The proportions of the ingredients are, orthoclase 43, gray quartz 44, white oligoclase 9, black mica 4.—*Bull. Geol. Soc. de France*, vii, 487.

Mineralogical Notes from the correspondence of Prof. B. Silliman, Jr., dated Italy, May and June, 1851.—Prof. Scacchi published in 1849 a memoir on the Campania, entitled, "Memorie Geologiche sulla Campania," 4to, pp. 131, with 4 plates, Naples. *Misenite*, a new species described in this work by Prof. Scacchi is a sulphate of potash, having the composition $2SO^3\,KO, HO$.

The *Scacchite* is a silicate of lime and alumina containing fluorine, and occurs in square prisms highly modified.

Leucite occurs at Vesuvius in the older ejected blocks as well as the most recent lavas, and it is observed in some instances undergoing a change to Ryacolite, while still retaining the external form of leucite, and sometimes cavities of ryacolite crystals are formed in the leucite.

Zircon occurs at Vesuvius in beautiful white and blue octahedrons in the old ryacolite gangue. *Fluor spar* occurs in octahedrons with hornblende in the older lavas.

Forsterite is identical with anorthite.

Davyne is regarded by Prof. Scacchi as a variety of *Nepheline.* The 6-sided prisms are striated longitudinally, and are modified by a plane on the terminal edges, and another on the lateral; it occurs in a compact pyroxenic gangue, while the Nepheline occurs in a gangue of ryacolite.

Arragonite is formed in an old mine at Monte Vasa from day to day, at a temperature below that of boiling water.

Buratite comes from Campiglia in the Maremma Pisena in Tuscany, and not from Volterra.

Tourmalines of Elba.—In the Grand Duke's collection at Florence there is a specimen 11 inches square, with four erect

green tourmalines and one prostrate, 2, 4, and 2½ inches long, and ¾ to 1 inch thick. They are associated with orthoclase and crystallized quartz. The pink tourmalines of Elba have always the basal plane 0R, while the green prisms are terminated with rhombohedral planes.

Analcime?—A singular Analcime-like mineral occurs at Monte Catini, in which the soda replaces magnesia, according to Prof. Meneghini of Florence, who obtained for its composition—

$\ddot{S}i$	$\dot{A}l$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
59·347	22·083	10·250	0·450	0·015	7·560

[This result gives the oxygen ratio for the protoxyds, peroxyds, silica and water 1 : 2 : 6 : 1⅓.]

Blowpipe test for Sulphur.—The test for sulphur by means of the nitro-prussid of soda, is suggested by Prof. J. W. Bailey, in volume xi, of this Journal, p. 351. The following are more minute directions for the use of this elegant test.

Heat by blowpipe any sulphuret or sulphate (or any thing containing sulphur) upon charcoal with carbonate of soda, put the fused mass into a watch glass with a drop of water, and add a particle not larger than a pin's head of the nitro-prussid of soda; there will be a magnificent purple at once. If this test for sulphur is tried upon parings of nails, hair, albumen, &c., I would advise that the carbonate of soda be mixed with a little starch, which appears to prevent the loss of any of the sulphur by oxydation. If you wind up a piece of hair four inches long by coiling it around one point of a platinum support, then moisten it and dip it into the mixture of carbonate of soda with starch, and then heat by blowpipe, the fused mass will give with the nitro-prussid an unmistakable action indicative of sulphur. This experiment any one can repeat. By careful management I obtained perfectly satisfactory results from a piece of hair less than an inch long.

Hausmann on the Artificial Formation of Minerals, (Beit. z. Met. Krystallkunde, Göttingen, 1850.)—The species which Hausmann enumerates as forming about furnaces from furnace action are the following; silver, lead, copper, iron, bismuth, galena, blende, oxyd of zinc, red copper, specular iron, magnetic iron, chrysolite, an iron-magnesia, pyroxene containing alumina, $(\dot{F}e, \dot{M}g)^2\,(\ddot{S}i, \dot{A}l)^2$, chytophyllite, humboldtilite, orthoclase, lead vitriol, arsenate of copper? and arsenate of nickel.

Brown, yellow, green and black blende have been formed in the furnaces of the Lauten valley in the Hartz, in regular octahedrons with modified edges and in dodecahedrons. Blende also occurs lamellar or even radiated.

Galena also is often formed by sublimation in the chimneys of furnaces, and the crystals are uniformly cubic with the usual

cleavage. Octahedral and cubic crystals of *magnetic iron* sometimes incrust cavities in the stone or brick work of the furnaces.

The chytophyllite, (p. 35,) has the formula (Ḟe, Ċa) ($\ddot{S}i$, Äl), and consists of

$\ddot{S}i$	Äl	Ḟe	Ċa
54·897	5·078	20·794	20·346=101·115

It is foliated columnar, not unlike some kyanite, with the color pearl gray, having a shade of lavender blue. Luster of folia between vitreous and pearly; translucent, when thin. Specific gravity at 15° R. 2·940. H.=5·5. Breaks with difficulty being tough. B.B. fuses easily with intumescence to a greenish-black glass, not magnetic.

New American localities of Minerals; by F. B. Hough, A.M., M.D. (Communicated for this Journal.)—*Sulphate of Barytes*, in a highly crystallized form, associated with an extremely unctuous variety of specular iron ore and serpentine, on the farm of James Morse, in Gouverneur. Specimens from this place are full of angular cavities from the intersection of tabular crystals.

Chondrodite occurs abundantly disseminated through white limestone, about three-fourths of a mile west of Somerville, in the town of Rossie. This is the only place where it has been observed *in quantity* in Northern New York. It is associated as usual with

Spinel, in perfect octahedrons with but few modifications. The latter mineral is of a pale rose color, and when in small crystals, is nearly transparent. They occur from an inch to less than a line in diameter and are frequently grouped together in great numbers. The large crystals are quite rare, but the smaller ones are common.

Apatite, in the town of Gouverneur, about two miles north of Somerville. Large crystals occur through the soil and in the subjacent limerock. Most of those hitherto procured have been from the partially decomposed rock.

One crystal had a length of one foot and a diameter of two inches. The form of the crystals is very perfect, except the terminal planes which are covered with pits and irregular indentations. The quality is very poor, but doubtless translucent and highly colored specimens might be obtained from the rock.

Sphene, in large brown crystals, has been obtained from the town of Macomb, in the vicinity of Pleasant Lake. The quality is very inferior, and crystalline form imperfect.

Galena and *Zinc Blende*, have been observed in considerable quantities in the town of Macomb, about half a mile from the Wilson Lead Mine. It is on the land of James Averil, and is owned by that gentleman and Messrs. Wilson and Smith. These ores occur disseminated through a friable limestone rock, to the width of several feet, and promise a profitable yield of these met-

als. *Carbonate of lead* in a white powder is the only associated mineral of interest.

Crystallized Specular Iron ore, associated with elegant crystallizations of quartz, have been discovered on the farm of J. Smith, in Gouverneur, St. Lawrence county.

Phlogopite, in large plates and spheroidal concretions, and containing minute crystals of *garnet*, has been obtained in considerable quantities in a working for iron ore in Gouverneur, near the mill of R. K. Smith. The mica crumbles soon when exposed to the weather. *Crystallized specular iron ore* is associated with it.

Arragonite, in snow-white concretions on surfaces of iron ore, at a new working at the Parish iron mine in Rossie, St. Lawrence county.

Tremolite, in great variety and abundance on the farm of F. Arnold, in the town of Diana, Lewis Co., associated with white limestone.

Notices of Localities in New England; by Mr. Jas. J. H. Gregory, of Marblehead, Mass. (Communicated to one of the Editors.)

Sullivan, N. H.—Tourmalines! In quartz, of a deep brilliant black, with terminal planes; found about a mile south of the center of the town.—Beryls are *said to be* found in the same locality.

Surry, N. H.—Amethyst; in the great railroad cut imbedded in calcareous spar, but now rare. I was informed that they had been found in other parts of the town. Calc spar, variety called *nail-head spar*, in slabs lining seams in the granite.

Grafton, N. H.—Garnets; from a quarter of an inch to an inch in diameter; well crystallized, but of a dull color and with faces unpolished: very easily obtained from decomposing slate rock.

Hartford, Vt.—Calcareous spar, in masses in a ledge cut through by the railroad near the Connecticut river.—Iron pyrites, crystallized in cubes, some of which are two, three, and four inches in diameter and have a good polish, considering their size. Found in a ledge about one-fourth of a mile from the calcareous spar.—Kyanite, in numerous crystals large and distinct, but those I have seen are not generally of a rich color; perhaps this may be accounted for from the fact of their being blasted from the surface. Occurs in numerous veins passing through mica slate, near Hartford center.

Bethel, Vt.—Actinolite! In brilliant crystals in talc. Found very abundantly in a dyke passing through a hill.—Steatite, containing crystals of bitter spar.

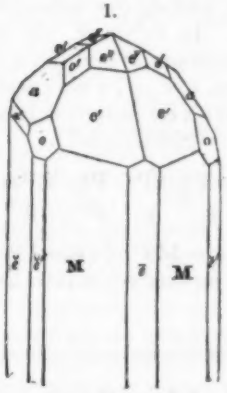
Royalston, Mass.—Mica! at a locality situated about four miles beyond the old one in South Royalston. The mica is of

a brilliant bronze, crystallized on three sides, and affords specimens much superior to those of the old locality.—*Beryls!* The beryls approach nearer to aqua-marines and generally are of a smaller size, and clearer, than those of South Royalston. Those of a sky-blue in the white quartz are very beautiful.—*Feldspar.* In crystals of the same form as those of the old locality, large and scarce. These minerals occur in worn granite on the farm of Mr. Solyman Heyward or Heywood.

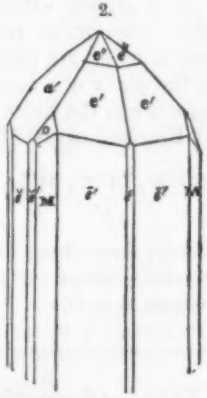
ART. XLI.—*On the Crystallographic Identity of Eumanite and Brookite;* by J. D. DANA.

A FEW days since, I received for examination from Mr. J. E. Teschemacher of Boston, two minute crystals of the Eumanite of Prof. Shepard. They had been long in his cabinet, and were procured from a specimen of the Chesterfield vein, the same locality that afforded the Eumanite. They have the same dark brown color, with a deep brownish red translucence, "like almandine garnet." The hardness, as Mr. Teschemacher observed, is about 6, or not above 6, scale of Mohs. A comparison of the figures here given will make obvious the identity of the two; figure 1 represents Prof. Shepard's crystal, figure 2, Mr. Teschemacher's.

1.



2.



The latter is only $\frac{1}{3}\frac{1}{5}$th of an inch in length, and as no reflection of distinct images could be observed on account of its minuteness, I was compelled to adopt the less accurate mode of measurement by a reflection of the sun's rays. The result has proved that Eumanite and Brookite are very closely similar, not only in physical characters, but also in crystallization. The two crystals strikingly differ though so nearly alike in form. The lateral planes which are the largest in figure 1, are quite small in

figure 2, and, the large lateral planes of figure 2 are wanting in figure 1. The angles obtained are as follows, together with those given by Shepard and the corresponding angles of Brookite.

	Eumanite. Shepard.	Eumanite. Dana.	Brookite.
$\breve{e}'' : \breve{e}''$		100°–101° (fr. $\breve{e} : \breve{e}$)	100°–100° 35′
M : M	123°	123° 08′ (fr. $\breve{e} :$ M)	
"		121°–124° (observed)	
$\breve{e}' : \breve{e}'$		139°–142°	
$a' : a'$ (over base)		102° 11′ (fr. $a' : a'$, over summit)	102° 24′, Levy.
$a' : a'$ (over summit)		77° 49′	
M : $\breve{e}$	118°–118° 30′	118° 26′	
$\breve{e}$: $\breve{e}'$		108°–110°	
$\breve{e}$: $\breve{e}''$		130°–130° 30′	130°–130′ 18
M : e′	136° 0′		
e′ : e′	151° 30′	150° 12′	
e′ : e″	159° 30′	159° 28′ (fr. $\breve{e}'$: e′ and e″)	
$\breve{e}'$: e′		140° 02′	
$\breve{e}'$: e″		119° 30′	
$\breve{e}$: a	127° 40′		
$\breve{e}$: a'		141° 5 (*calc.* fr. $a' : a'$)	
a : e′	127° 30′		
a : o	144° 20′		
$\breve{e}$: o	128° 20′		
e′ : o	156° 30′		

The first two of the angles of Brookite mentioned are angles of a vertical and horizontal prism, and consequently they determine the dimensions of the crystal and prove the identity as perfectly as if all the other angles were added, the others being deducible from these by calculation. In figure 2, the edges between $\breve{e}$, e′, e″ are parallel; those between a' and the o either side of the plane a'; and those between o, e′, e′, o are parallel.

Figure 2 has the faces, (adopting Levy's fundamental form and axes of Brookite, $a = 0{\cdot}5558$, $b(\breve{e}$ to $\breve{e}) = 0{\cdot}5957$, $c = 1$),

$$\underset{\breve{e}}{\alpha\bar{P}\infty}\ ,\ \underset{a'}{\tfrac{4}{3}\bar{P}\infty}\ ,\ \underset{o}{2\breve{P}\tfrac{3}{2}}\ ,\ \underset{\breve{e}'}{\alpha\breve{P}2}\ ,\ \underset{M}{\alpha\breve{P}3}\ ,\ \underset{\breve{e}'}{\alpha P\tfrac{9}{2}}\ ,\ \underset{e'}{2P\tfrac{9}{5}}\ ,\ \underset{e''}{P\tfrac{9}{2}}\ ,\ \underset{\breve{e}}{\alpha\breve{P}\infty}$$

Calculating from these axes gives, $e' : e' = 149°$, $\breve{e}' : e' = 139°\ 53'$, $e'' : e'' = 159°\ 20'$, $\breve{e}' : e'' = 120°\ 41'$, $o : o$ (over e′) $= 100°\ 26'$.

New Haven, Sept. 23.

Art. XLII.—*Observations on the Pendulum Experiment;* by Rev. C. S. Lyman.

The fact that the plane of vibration of a free pendulum has a movement in azimuth around the vertical, had been observed by many experimenters, before it was brought so prominently into notice by M. Foucault in connection with the rotation of the earth. This movement is distinctly described, and illustrated by a figure, in some manuscript observations on the motion of a

pendulum by the Florentine Academicians, but without any intimation of its cause. That such a motion was to be expected, was also suggested by the Marquis de Poli, (Phil. Trans., 1742,) and by Poisson in 1837, but without giving the subject any further attention, or attempting to test it by experiment.

The observed independence of the plane of oscillation of a vibrating steel rod inserted in the revolving arbor of a lathe, appears first to have suggested to M. Foucault the idea that the plane of vibration of a free pendulum would, in like manner, be independent of the rotation of the earth.

The experiment was first tried by him with a pendulum six and a half feet in length suspended from the vaulted roof of a cellar, and with entire success. It was subsequently repeated, in connection with M. Arago, at the Paris Observatory, with a pendulum thirty-six feet long. This was in February, 1851. Since that time the experiment has excited general interest, and numerous repetitions of it have been made both in Europe and America.

We propose in the present article to give a general summary of information on this subject, derived partly from published accounts, and partly from our own experiments.

1. *The method of suspension.*—Foucault used a fine steel wire inserted at the top into a hole just large enough to receive it, made in a steel plate which was fastened to the ceiling. The same method of suspension was employed by Mr. Bunt at Bristol, England, by Profs. Carswell and Norton at Providence, R. I., in the experiments at the Capitol in Washington, and in those at New Haven. Indeed this appears to have been the mode generally adopted by those who have repeated the experiments. At the U. S. Armory in Springfield the suspension at top was by means of a pointed steel pivot resting on a hard surface, and the same method has been elsewhere tried, both in this country and in Europe, with a view, probably, in most cases, to avoid friction, but in others, perhaps, to obviate the supposed prejudicial effect of the rotation of the point of support—a matter which, as we shall see, is of no consequence whatever. Others have devised more complicated modes of suspension, such as gimbals with knife edge pivots, the principle being that on which chronometers, marine compasses and barometers are suspended.

But besides the danger of errors arising from imperfect workmanship in these complicated devices, it is not certain that they present any advantages over the first named method, viz., the insertion of the upper end of the wire by soldering, or otherwise, in a firm metallic support. If the wire is equally flexible in all directions, this method is as good as can be desired, and whether the wire is thus flexible or not, may be ascertained experimentally in the manner suggested by Prof. Bache at Washington; namely, by placing the portion of the wire at which the flexure

is to take place in a horizontal position, and after attaching a small weight to the extremity of it, observing whether the weight bends it down always to the same extent while the wire is turned around on its axis. If any error in the movement of the plane of vibration of the pendulum is due to a different flexibility of the wire in different directions, the effects of it may be eliminated by so constructing the support to which the wire is attached that it can be shifted in azimuth during the experiments.*

2. *Length of Pendulum wire and weight of ball.*—The greatest length hitherto employed was that of 220 feet, at the Pantheon at Paris. The pendulum at Bunker Hill Monument was 210 feet long. That used at Providence was 97 feet, that at New Haven 71 feet, while in Great Britain and on the continent, few of the pendulums used were over 50 or 60 feet in length. In many cases they have been less than ten feet; and even with these the change in the direction of the plane of oscillation is clearly shown. The weight of the ball employed has been very various, ranging from two to eighty or ninety pounds; and it has usually been made of lead, which, on account of its great specific gravity, is better adapted to this purpose than any other of the ordinary metals.

Iron has been suspected by some to be an unsuitable material on account of its magnetic qualities. Mr. Bunt at Bristol, from some experiments with an iron weight, in which he was troubled with very anomalous results, inferred that it was owing to the influence of magnetic currents. But it is difficult to conceive how the fluctuating irregularities which he observed, could be produced by such a cause; and, besides, M. Bravais, in his experiments on the revolutions of a conical pendulum, employing a weight composed of mercury enclosed in some experiments in a copper shell and in others in one of iron, could detect no difference in the results, and concluded from his very delicate experiments, that the iron exerted no sensible influence whatever.

It is obvious that the longer the wire and the heavier the ball of a pendulum, the greater will be the probability of accurate results. For the resistance of the air being proportional to the square of the velocity of a body moving in it, this resistance when the mass of the body is great and its motion slow, will have comparatively but little effect on the direction of the vibrations. This is the main reason why short pendulums do not succeed as well as long ones.

3. *Length of the arc of vibration.*—It seems to have been an object with most of the European experimenters to give the

* Some have completed the suspension at top by means of softened catgut or silk cord, as at York, England, by Mr. Phillips. But the great ellipticity of the path of his pendulum and the irregularities in the results do not strongly recommend such a method.

pendulum a very wide swing, for the purpose doubtless of having the motion of the plane of vibration, measured on the graduated periphery of the circular table, as obvious as possible. From 7 to 20 feet appears to have been the common measure of the arc of oscillation with pendulums of from 50 to 200 feet in length. For the purpose of exhibition to popular audiences this scale of vibration is doubtless desirable, and the slow measured sweep of the ball of a long pendulum is a very beautiful sight. But for the purpose of philosophical observation a smaller arc is much better. Not only is the resistance of the air proportionately less, but the tendency to an elliptic motion is greatly diminished, and the ease of marking the apparent motion of the plane much increased. A total arc of vibration of 2° or 3° is preferable to one of 8° or 10°. The former corresponds to an arc of from two to three feet in a 60 foot pendulum, instead of 8 or 10 feet, which is a length given it by many experimenters.

4. *Sources of error.*—These are so numerous and obvious, yet difficult to avoid, that the wonder is, not that the experiments exhibit some discrepancy in the results, but that they show so little. Poinsot reasoned that the rotary motion of the earth must tend to affect the plane of a pendulum's vibrations, but concluded that the effect would be too small to become sensible.

The effect of a different degree of flexibility in the suspending wire in one direction from that in another, will be to vary the apparent motion of the plane of oscillation, according to the position of that plane in respect to the direction of maximum or minimum flexibility of the wire. If the wire has not been well straightened, but retains a tendency to coil, this also must necessarily exert an influence on the position of a plane which depends for its persistency solely on the inertia of the vibrating body.

The pendulum weight must be a true solid of revolution, with its centers both of figure and gravity strictly in the line of suspension. If it be not so, the unequal action of the air on different parts of its figure will be sure to vitiate the results. Whether this coincidence of centers actually exists can only be determined by careful trials; for the figure may be perfect and all look well to the eye, while yet one part of the casting may, for some reason, be considerably more dense than another, or contain concealed air-bubbles, which will have the same effect on the results.

Undoubtedly the worst difficulty to be encountered is the effect of currents of air. Even if the air were perfectly motionless in respect to the apartment, yet moving with the apartment along with the earth in its rotation, it must tend to carry the ball along with it around the vertical, and thus, in some degree, diminish the amount of motion which the plane of vibration would otherwise have. But besides this effect, the air must produce other and still greater disturbances, in consequence of the cur-

rents into which it is constantly liable to be thrown. Few apartments are closed perfectly tight; or if there be no currents from this source, the motion of the observer in the room, his respiration or the heat of his body, will constantly tend to disturb the equilibrium of the air; and how great an effect on the delicate movements of the pendulum the slightest current will have, may be learned by breathing ever so gently towards such a pendulum when in motion. A single breath will throw it into an elliptic path and sensibly change its plane of oscillation.

One great source of the elliptic motion so constantly observed in these experiments undoubtedly is the almost insensible lateral oscillation which the pendulum is apt to have at the moment of being let off, notwithstanding the utmost care that may be taken to extinguish it. Perhaps as good a way as any to secure perfect quiescence at this moment, is to bring some smooth surface, like that of an ivory scale, into contact with the point of the pendulum index, while the other end of the scale resting as the short arm of a lever, on some solid support for a fulcrum, is gently pressed by the finger. In this way the contact can be delicately renewed and broken till the slight friction on the point of the pendulum gradually brings it to rest.

The common method of starting the pendulum by suddenly letting loose the single thread attached to the loop which retains it, is perhaps the best that can be employed.

5. *Phenomena observed.*—When a pendulum, freely suspended as before described, is put in vibration, the plane of oscillation is seen gradually to change its position in reference to the points of the compass, or to have a horizontal movement of rotation around the vertical from left to right, or with the motion of the hands of a watch.

The *rate* of this angular motion has been the point to which most persons who have repeated the experiment, have directed their attention. It has been observed to be different in different places, and to correspond approximately to the amount assigned by mathematical investigation, namely, the angular motion of the earth on its axis multiplied by the sine of the latitude. A further examination of this expression for the rate of motion will be given further on.

The rate of motion per hour, however, as given by experiment, is by no means a constant quantity, even at the same place and with the same pendulum, varying often in different trials a degree, and sometimes two or three degrees, from the mean, or from the theoretical amount.

Mr. Thomas G. Bunt, of Bristol, describes in several papers published in the Philosophical Magazine, the results of numerous experiments made at Bristol, with a pendulum 53 feet in length and weighing 53½ pounds; to which he gave, in his earlier ex-

periments, an arc of vibration of about seven feet, but in his later ones, of one or two feet only. Mr. B. appears to have taken much pains to note the amount of elliptic motion which the pendulum acquires, and applied to the observed angular motion of the plane of vibration certain corresponding corrections, to obtain his tabulated results.

The following table contains the observed rate of motion, and other particulars of the experiments, at the several places named. We regret that the results of the experiments of Prof. Horsford, at the Bunker Hill Monument, are not within our reach.

Place.	Length of pendulum.	Initial arc of vibration.	Observed motion per hour.	Calculated motion per hour.	Latitude, North.	Whole time observed.	
			°	°	° ′	hours	
Bristol, Eng., . .	53 ft.	8 ft.	12·097	11·763	51 27	26½	
(T. G. Bunt,) . .	"	"	11·945	"	"	. .	Mean of preceding with additional experiments.
	"	4 ft.	11·677	"	"	37	Corrected for ellipticity
	"						
	"	14 in.	11·651	"	"	4	
	"	short	11·750	"	"	326½	41 trials uncorrected for ellipticity.
Dublin, . . .	35 ft.	4 ft.	11·900	12·073	53 23	. .	(Galbraith and Haughton.)
York . . .	52	14 ft.	13·12	12·163	53 58	. .	4 trials.
(J. Phillips,) . .	5½	18 in.	11·94	"	"	. .	4 " weight $1\frac{1}{12}$ lbs.
Geneva, Sw., . .	66½	11 ft.	11·848	10·856	46 12	9	4 " E. and W.
(Dufour & Wartmann)	"	"	10·522	"	"	9	4 " N. and S.
New York City, .	9 ft.	—	9·733	9·815	40 44	—	(Prof. Loomis.)
Providence, R. I., .	97	5 ft.	9·955	10·030	41 49½	—	16 trials, (Profs. Carswell and Norton.)
New Haven, Ct., .	71	3 ft.	9·970	9·928	41 18½	18	16 trials.

The calculated motion per hour in the fifth column, is the actual angular motion of the earth, considered as around the vertical, in one hour of *mean solar time*, and of course is somewhat greater than the product of 15° into the sine of the latitude, which gives the motion in one hour of *sidereal* time.

From this table it will be seen that the observed rate of motion of the plane of vibration per hour, as nearly coincides with the product of the hourly motion of the earth on its axis into the sine of the latitude of the place as could reasonably be expected, considering the many obstacles in the way of accurate results. Some of the observations noted in the table appear not to have been very skillfully conducted, particularly those at York, where the ellipticity sometimes amounted to three or four inches for the minor axis, and was not considered measurable unless it exceeded one-fourth of an inch. The discrepancy among the individual observations was accordingly very great.

The experiments at different places have generally seemed to show, that the rate of motion of the pendulum plane is not at

all affected by the direction of the vibrations in respect to the points of the compass.

Messrs. Dufour and Wartmann, however, at Geneva, found the rate to be less in their experiments, when the vibrations were in the direction of the meridian than when at right angles to it, as may be seen from the above table. Hence Gen. Dufour infers, that the formula $A'=A$ sin. lat., (A=angular motion of the earth, and A' the motion around the vertical, or that of the pendulum plane,) is not rigorously applicable. M. Morren at Rennes comes to a similar conclusion from his own experiments.

But besides the difficulty of conceiving any physical cause for such a difference, the fact that other experimenters have not noticed it, (although their experiments appear to have been both more extensive and conducted with at least equal care,) may lead us to hesitate about adopting such a conclusion, especially when the results of rigid mathematical investigations of the problem reveal nothing of the kind, but give as an exact expression of the the motion of the pendulum plane the simple formula just referred to. The disturbing causes connected with such experiments are too numerous, and too difficult to be avoided, to allow of any such broad inference being drawn, except as the result of long continued observations, made with reference to every variety of circumstances.

It has also been noticed by some observers, that the rate of motion of the pendulum plane in a single trial, is *not uniform*, but varies in the course of the experiment; generally becoming more rapid as the arc of vibration diminishes. In the experiments at New Haven this acceleration of rate was noticed in a majority of the experiments, though it was much more perceptible in some cases than in others.

Five experiments, in which the pendulum was permitted to vibrate till its plane had passed over 10° on the horizontal circle, gave the times of passing over the first five and last five degrees of the arc, as follows; the pendulum being 71 feet in length, and weighing 12 pounds.

	Time of first 5°.	Time of second 5°.	Length of arc of oscillation at 0°.	Length of arc of oscillation at 5°.	Length of arc of oscillation at 10°
	m. s.	m. s.	inches.	inches.	inches.
1	29 20	28 0	44	26	18·5
2	30 50	30 0	40·5	25	17·5
3	31 5	30 25	40·6	25·2	17·5
4	31 30	31 30	46	27·4	18·6
5	31 50	31 10	44		
Mean.	30 55	30 13			

This varying rate of motion appeared to have no connection, in the experiments at New Haven, with the elliptic motion which the pendulum acquires; for it was often most marked when the

motion of the apses of the ellipse was least, and sometimes even took place directly in opposition to the effects of that motion.

In any series of experiments at the same place and with the same pendulum, there is observed, as was remarked before, considerable *difference* in the rate of motion of the pendulum plane in different trials. Mr. Bunt's results for the hourly rate of motion sometimes differ nearly 3° from each other—though his experiments appear to have been very carefully conducted.

The experiments of Mr. Phillips at York, present still greater discrepancies. At New Haven the rate of motion per hour in different trials, always fell within half a degree of the mean, as will be seen from the following table, which presents more in detail the observations of which some general results were given in a previous paper.

	Time.	Part of azimuthal circle passed over.	Length of arc of vibration at beginning.	Length of arc at end.	Minor axis of ellipse.	Direction of motion in ellipse	Motion of plane of vibration per hour.	Motion of apses of the ellipse per hour.	Motion of plane corrected for ellipticity.
	min.	° °	inches.	inches.	in.		° dec.	°	
1.	41·5	0–7	48·0	23·0	0·02	R	10·12	−0·01	10·11
2.	117·0	0–20	55·0	11·6	·01	R	10·26	− ·01	10·25
3.	36·3	0–6	50·8	27·2	·06	R	9·92	− ·02	9·90
4.	184·2	0–30¾	36·6	6·0	·10	R	10·00	− ·03	9·97
5.	60·8	0–10	40·4	17·4	·20	L	9·87	+ ·06	9·93
6.	61·5	0–10	40·6	17·4	·10	L	9·75	+ ·03	9·78
7.	63·0	10–20	46·0	18·6	·30	L	9·52	+ ·08	9·60
8.	172·8	90–120	44·0	7·2	·16	R	10·41	− ·04	10·37
9.	29·0	90–95	43·4	26·8	·12	R	10·34	− ·04	10·30
10.	61·5	130–140	44·8	18·6	·04	R	9·75	− ·01	9·74
11.	29·5	40–45	48·6	29·8	·10	L	10·17	+ ·04	10·21
12.	95·2	170–185	39·0	12·2	·08	L	9·46	+ ·02	9·48
13.	17·3	130–133	. .	34·4	·08	R	10·28	− ·03	10·25
14.	23·7	41–45	. .	30·0	·00	. .	10·13	·00	10·13
15.	36·3	89–95	46·0	26·0	·06	R	9·92	− ·02	9·92
16.	49·7	0–8	43·0	20·6	·06	L	9·66	+ ·02	9·68
							9·97		9·97

The zero of the horizontal circle was nearly in the meridian. The mean rate of motion, it will be observed, a little exceeds that given by the rule of the sine of the latitude, which is 9°·928, or 9° 55′ 43″ per hour of mean solar time. The number of observations made was not sufficiently great to eliminate entirely the effects of errors of observation, or give anything more than an approximate mean result.

Ellipticity.—The tendency of the pendulum to move in a narrow ellipse, instead of a straight line, has been remarked by all observers; and the degree of ellipticity has, it is believed, been uniformly observed to increase during the progress of the experiment, at least until the arc of vibration had become very short. The ellipticity may be considered of two kinds, the *necessary*, and the *accidental*.

The slight ellipticity which must necessarily be given to the motion of the pendulum by the rotation of the earth itself, has

been perhaps sufficiently illustrated in an article on page 251 of this volume. Such an ellipticity may be produced in an exaggerated degree, by suspending a pendulum from an arch over a whirling-table, so that it may hang when at rest directly in the axis of motion. If the pendulum ball be drawn aside to the periphery of the table, and detained there by a catch, while the table is made to revolve, on being let loose instead of falling in a straight line through the point of rest, or center, it will describe an elliptic orbit, whose minor axis will be proportioned to the tangential velocity of the ball at the moment it is disengaged. If that velocity be sufficient to carry it a quarter round the periphery of the table in the time it would move by the force of gravity to the center, or make half a vibration, the centrifugal and centripetal forces will balance each other, and the pendulum when let loose, move in a circle, with the same rate of motion as that of the circumference of the revolving table.

In the ordinary pendulum experiments, this ellipticity, owing to the slowness of the tangential motion given to the ball by the rotation of the earth, must be very slight; so slight, indeed, as to be nearly or quite insensible to direct observation, being lost amid the accidental sources of elliptic motion, unless the experiment be conducted on an extensive scale. The longer the pendulum and the larger the arc of vibration, the greater will be the minor axis of the ellipse.

The following formula, deduced by Prof. Stanley of Yale College, from a consideration of the forces by which the pendulum is governed, viz., $B=V\frac{2t}{\pi}$, expresses the length of the semi-minor axis (B) in terms of the tangential velocity (V), and time occupied in a semi-vibration of the pendulum (t). Then, A being the length of the semi-chord of vibration, or radius of the circle in which the ball receives its tangential velocity from the earth's rotation, $V=\sin.\lambda\frac{2\pi A}{86400}$, and consequently, $B=\sin.\lambda\frac{2\pi A}{86400}\times\frac{2t}{\pi}=\sin.\lambda\frac{At}{21600}$, λ being the latitude of the place.

For the latitude of New Haven, (41° 18′ 24,″) with a pendulum making a half vibration in $2^{s}\cdot33$, and having a chord of vibration of 4 feet, this would give for the minor axis of the ellipse, $0^{in}\cdot0034$. In the latitude of Paris, with a pendulum 220 feet long, and vibrating 20 feet, the minor axis of the ellipse would be $0^{in}\cdot0344$, nearly $\frac{1}{2^{5}_{9}}$th of an inch, a quantity easily appreciable in careful observations.

Whether this ellipticity will tend to develop itself in a series of experiments by causing a preponderance of motion in one direction

rather than the other, is somewhat doubtful. Many of the published observations, especially those with long pendulums, seem to indicate such a result. At Providence the motion in three-fourths of the trials was towards the left. With shorter pendulums the ellipticity in each direction seems to have been about equal—though in Mr. Bunt's long series the preponderance was also towards the left.

But the most marked ellipticity, and the one constantly observed in these experiments, is that which may be considered as accidental, and which varies both in amount and direction in different trials. In the experiments at New Haven, the minor axis of the ellipse rarely exceeded a tenth of an inch. Mr. Bunt in some of his trials, and several others, have found it equally small; while others, owing doubtless to a faulty apparatus, or to aerial currents, or unskillful managemennt, have found it amount sometimes to two, three or more inches.

This motion in an elliptic orbit, from whatever source it may originate, necessarily gives rise to a progressive motion of the apses of the ellipse in the same direction in which the orbital motion takes place.

Mr. Airy the Astronomer Royal, Mr. Galbraith of Dublin, and Mr. Thacker of Cambridge, have investigated the nature of this motion, and have given as the result of their inquiries, essentially the same formula for computing the progressive angular motion of the apses of the ellipse. These formulæ, together with the extended analysis of Messrs. Galbraith and Haughton, are published in the August number of the Philosophical Magazine.

The Astronomer Royal concludes from his investigation that, "If the length of the pendulum be a, the semi-major axis of the ellipse described by the pendulum be b, and the semi-minor axis be c, then the line of the apses of the ellipse will perform a complete revolution in the time of a complete double vibration (i. e. the time of describing the ellipse) multiplied by $\frac{8a^2}{3bc}$."

To reduce this to a convenient form for computing the progressive motion of the apses of the ellipse per hour, let m represent that hourly motion, T the time of a complete revolution of the apses, and t the time in seconds of a double vibration of the pendulum; then, as above, $\mathrm{T}=t\frac{8a^2}{3bc}$. But, ($T$ being in seconds) $m=\frac{360^\circ}{\mathrm{T}}\times 3600$. Substituting the above value of T,

$$m=\frac{360^\circ\times 3600\times 3bc}{8a^2t}=486000\frac{bc}{a^2t}.$$

If $a=71$ feet$=852$ inches, $t=9{,}333$ seconds, $b=24$ inches, and $c=0{\cdot}2$ inches, (b and c being the arithmetical mean of the

values of these quantities at the beginning and end of the experiment,) then, $m=\frac{486000\times24\times0{\cdot}2}{(852)^2\times9{\cdot}333}=0°{\cdot}3443=0°\ 20'\ 39''{\cdot}5$ per hour.

In this manner were computed the corrections for ellipticity given in the last column but one of the table on page 405. It will be seen from this table that the motion of the apses of the ellipse as given by the formula, accounts for but a small part of the difference between the observed rate of motion of the pendulum plane and that which it would have were there no elliptic motion. It must be remembered, however, that the formula does not take into account the resistance of the air, and other fruitful sources of disturbance. The agreement of the formula with the differences in the rates of motion observed by Mr. Bunt is somewhat closer.

The motion of the apses of the extremely narrow ellipse that has been spoken of as arising from the earth's rotation, must tend slightly to diminish the rate of motion of the pendulum plane, since it takes place in the same direction as the motion of the earth. This effect, however, will be entirely insensible, since, even with a pendulum 220 feet in length and vibrating 20 feet, it amounts to only a little more than $3''$ of arc per hour.

6. *Connection of the motion of the pendulum plane with the earth's rotation.*—Many persons, even of education, find it difficult to understand how a vibrating pendulum, whose line of suspension must constantly be directed to new points in space as the earth revolves, can exhibit any thing like permanency in the position of its line of vibration with respect to the rotating motion of the earth. It is true that the path of the pendulum ball, considered as in absolute space, is exceedingly complicated, being compounded of its own oscillating movement, the motion of the earth on its axis, and of the earth itself around the sun. But it is not at all necessary to attend to this complication of motions in the problem before us.

In the first place let it be observed, that the direction of the plane of vibration of a free pendulum is entirely independent of any motion, whether of rotation or of translation, that the point of suspension may have. Hold in the fingers a pendulum made of a simple ball and string, and cause it to vibrate; then twirling the string between the fingers will only cause the ball to rotate on its axis, without affecting at all the direction of the vibrations; and walking forward, whether in a straight line or in a circle, will in like manner, only shift the position of the entire pendulum, which will continue to vibrate towards the same point of the compass as at first.

Again let it be noticed, that the direction of the force of gravity being constant, that is, towards the center of the earth, the

relation of the pendulum to that force must also be constant, and its motion is to be treated, not absolutely or in reference to space, but precisely as if the earth were at rest, the equal motion of both earth and pendulum having no effect on their mutual relations to each other, save in the relative change in the horizontal direction of the line of the pendulums vibrations, in consequence of the fact that that direction is entirely independent of the earth's motion, as we have just illustrated. The direction of the plane of vibration depends for its permanency on the *inertia* of matter, and whatever change may be made in the position of that plane in respect to space, or the heavens, by the earth's rotation, precisely the same change of position takes place in the earth itself, and as we have said, the direction of gravity in respect to both remaining the same, we are only required to consider the relative horizontal change that takes place in the angle made by the plane of vibration with a given line on the earth's surface.

At the pole the problem is extremely simple—the plane of vibration remaining constant, and the earth turning under it at the full rate of its angular velocity of rotation, or 15° per hour.

As we recede from the pole, the problem is, to find the true ratio subsisting between the earth's angular velocity of rotation and the latitude of the place, for at the equator both the latitude and motion of the plane are at zero, and no relative angular motion can be exhibited.

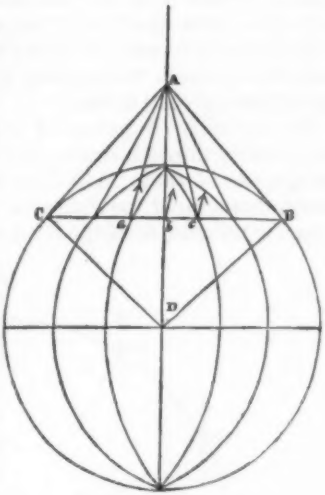
M. Binet, (Comptes Rendus, 1851, Nos. 6, 7), Rev. J. A. Coombe, (Phil. Magazine, No. 7, 1851), and other mathematicians, have investigated the problem on the method of resolving the rotary motion of one point on the earth's surface into two, one about the vertical to that point, and the other about an axis at right angles to it and lying in the direction of the meridian. If the motion took place wholly about the latter, which is parallel to the surface of the table over which the pendulum vibrates, the effect would be precisely the same as at the equator, for there this axis coincides with the earth's axis, and in either case there could be no relative motion of the plane. It is the other part of the resolved motion therefore, that is alone effectual in giving the table a virtual motion of rotation in its own plane about its center. If the motion were wholly around this axis, the case would be the same as at the pole, for there this vertical axis would coincide with the earth's axis, and the angular motion would be at its maximum. From these considerations equations are formed from which the exact angular change of position of a line on the earth's surface, considered as around the vertical, is shown to be proportional to the *sine of the latitude.* M. Binet enters into an analytical investigation, in which the conditions of the motion of the pendulum generally are expressed by certain differential equations, the integration of which conducts him to certain expres-

sions, which, when simplified by the consideration of limiting the vibration to small arcs, gives the azimuthal velocity uniform in the direction from left to right, and in the simple proportion of the sine of the latitude.

Prof. O'Brien of Kings College, London, in an article on Symbolical Mechanics, in the August number of the Philosophical Magazine, investigates the same problem, and concludes, "that the effect produced by the earth's rotation on the pendulum is proportioned in every respect to the sine of the latitude."

Perhaps the simplest and most satisfactory method of illustrating the subject to minds not specially trained to mathematical investigations, is that adopted by Prof. J. D. Dana, in a communication made to the Scientific Association at Albany, and published on page 200 in this volume; viz., by drawing lines parallel to each other along any circle of latitude on an artificial globe in the manner fully described in the article referred to.* These lines, it is true, taken as representing the successive positions and directions of the plane of vibration, are not strictly parallel, nor is it necessary to regard them as such, except when considered as placed at indefinitely small distances apart. The continually changing direction of the *axis of suspension* causes a corresponding change in the absolute position of these lines, and hence, considered as in space, they do not lie in the same plane, and of course are not in all respects parallel. But as precisely the same change takes place in the position of the horizontal plane over which the pendulum vibrates, and in the direction of the force of gravity, causing that direction to remain relatively constant, the relative effect, as has been remarked already, is exactly the same as if no such change of position occurred, or as if the successive positions of the line of vibration were in one continued plane, the line maintaining a constant parallelism to itself. But if these lines are parallel, why is not the last in the series, when we have gone round a circle of latitude, parallel to the first? This is not the case, because the lines, though relatively parallel, are not, for the reasons before mentioned, to be treated as absolutely so. They are to be regarded as lines drawn on the surface of a cone at its base—the cone being that formed by the successive meridional tangents to a given circle of latitude, and having its apex at the point where all these tangents meet the axis of the earth produced. Such lines, if not parallel, strictly speaking, when regarded as on the curved surface of the cone, will become truly so, when that cone, considered as made of paper, is cut open from its center outward and spread out on a flat surface.

* We have learned since that article was in type, that the same method of illustration has been used by Prof. Horsford.



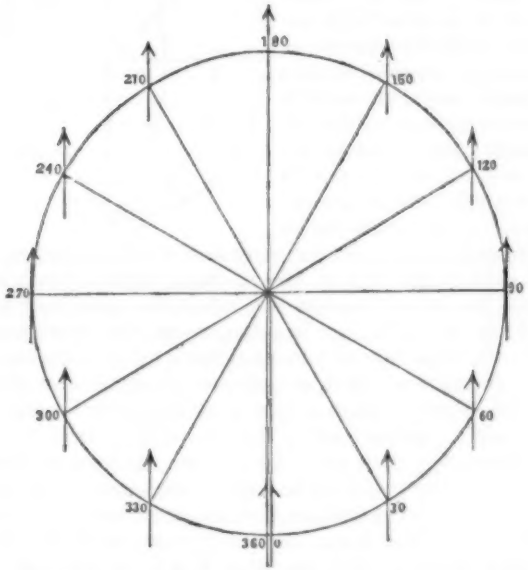
In the accompanying figure the cone formed by the tangents has for the periphery of its base the circle of latitude B C, and the inclination of any two meridians to each other at this parallel of latitude, is represented by the angle formed at the apex of the cone by the corresponding tangents. Let the arrows *a*, *b*, *c*, represent successive positions of the pendulum plane; now, as the earth revolves on its axis, the angle formed by this plane with the meridian, or rather with its tangent, is continually increasing, but evidently increasing not by an amount as great in a given time as the angular motion of the earth on its axis in the same time; for the motion of a place B going round with the earth at the rate of 15° an hour, takes place in a circle having for its radius the line B *b*, while the same motion of B considered as around A, (or in other words, the relative angular change in the direction of the meridian), takes place in a circle of which the radius is B A, a radius as much greater than the other as the hypothenuse of a right angled triangle is greater than one of its sides; consequently, the circumferences of circles being proportioned to their radii, the angular change in a given time must be less in the larger circle than in the smaller, and as much less as the line B *b* is less than B A, or as the sine of an angle is less than radius, (B *b* being the sine of the angle B A *b*, when B A is made radius.) But the angle B A *b*, in the right angled triangle A B D, is the complement of the angle at D, which latter is the complement of the latitude; consequently B A *b*=the latitude; B *b* is the sine of the latitude; and therefore the angular change in the direction of the meridian, and consequently the apparent motion of the pendulum plane, is proportioned to the sine of the latitude.

Now when the pendulum has made one complete revolution around the earth in the circle B C, it has evidently made but a part of a revolution in the circle of which A B is radius; and the total change of inclination of the parallel arrows drawn on a globe to the successive meridians in going once round the globe, must in like manner equal only a corresponding part of 360°. The last line in the series of quasi parallels, therefore, can only be parallel to the first, when the circuit has been made at the

equator, where both the meridians and successive positions of the pendulum plane maintain a perpetual parallelism.

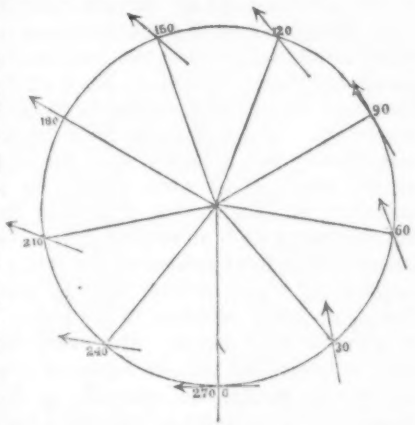
This varying rate of relative angular motion as we proceed from the poles to the equator, may be very simply illustrated by the following easy device.

Cut out a circular piece of paper, and draw radii from its center to every thirtieth degree, as represented in the figure. At the extremities of these radii draw a series of arrows, all parallel to each other around the entire circle. Cut open the paper from the center outwards, as at the double line in the figure.



This paper with its radii may be used to represent the cone formed by the meridional tangents, having the axis of the earth passing up through its apex or center, and its base resting on a parallel of latitude. At the pole, where the tangents touch the surface of the earth, and all lie in the same plane, the sum of all the angles which they form at the center, is equal to 360, as represented by the paper in its original flat condition, its circumference being entire. Let a pendulum be carried around the pole at an indefinitely small distance from it, say a few feet only, and the successive positions of its plane of vibration will be not only relatively parallel to each other, but may be considered as strictly so, as represented by the arrows in the figure. If now one edge of the paper where it is cut open, be lapped over the other, the center will rise and form the apex of a cone; and as one edge of the paper,

with the arrow parallel to it is slid around the surface so as to make the cone gradually more steep, it will be seen that the angle of inclination which the first arrow forms with each successive arrow that it meets, is continually increasing, and is precisely equal to the portion of the original circle that has been covered up by the over-lapping of the sides. Let the edge overlap for example one quarter of the circle, or cut off 90°, the cone will then be as in the accompanying figure.



All but 270° of the entire circle are seen to be concealed; the figures on the margin representing not the angles made by the radii on the present circle, but on the original one. But these 270 original degrees are made to encompass the entire base, or to equal the entire circle of latitude to which the base of the cone corresponds. Instead of 12 radii to the circle, as at first, there are but *nine* of the 12 left; hence each pair of radii, instead of including only 30 degrees of a circle of latitude, includes $30° \times \frac{12}{9} = 40°$, and the angles which the arrows make with the successive radii, viz., 30, 60, 90, &c. degrees are continually falling short of the corresponding angular motion of the earth, viz., 40, 80, 120, &c. degrees, so that when a complete circuit of the earth has been made, or 360°, the arrows have changed their relative direction only 270°, or fall 90 short of making an entire revolution in 24 hours, as will be seen in the figure. $\frac{270}{24}$ gives 11° 15′ for the motion of the plane of vibration per hour in the latitude contemplated. And as this latitude must be that, the entire circle of which is just $\frac{3}{4}$ths of the circle which has the slant height of the cone for radius, as appears from our first figure, it follows that the sine of the latitude must be just $\frac{3}{4}$ths of radius, or the latitude 48° 35′ 25″. When the sides of the paper are lapped so that 180° of the circle are concealed, the first arrow will be found to be parallel to that at the 180th degree, but pointing in an opposite direction, having performed half a revolution during an entire revolution of the earth. The base of the cone, being now just half its original periphery and diameter, corresponds to a latitude the sine of

which is just half of radius, that is, to the latitude of 30°. In this way the base of the cone goes on diminishing as compared with its height until we reach the equator, where the height of it in fact becomes infinite, and the tangents form a cylinder. Of course here the pendulum plane has no relative motion. South of the equator the conditions are reversed, and as we pass towards the south pole, the plane of vibration will be found to revolve in the opposite direction, or from right to left, and with a velocity as in the other hemisphere varying with the sine of the latitude.

7. *Modifications of the experiment.*—Various analogous methods of rendering sensible the earth's rotary motion have been proposed, but none of them, so far as we know, have yet been tested by actual experiment, except that of M. Bravais with a conical pendulum. Many of them have been devised on the mistaken assumption that a heavy body suspended above the earth, will, as the result of its own inertia, be independent of the earth's motion. M. Baudrimont (Comptes Rendus, No. 8, 1851,) not only proposes such an experiment, (a heavy ball suspended by a string as free from *torsion* as possible,) but even imagines, as he explains in a long article, that the principle may be applied, by having an index attached to the heavy body, to the construction of a *perfect time keeper*. But every such device, whether it be a ball, or horizontal rod, or balanced wheel, must fail of showing any results, except the oversight of the contriver, for the simple reason that it contains no provision for divesting the body of the movement which it has in common with the earth's surface, so as to leave it to be governed solely by its own inertia.

The experiment proposed by M. Poinsot (L'Institut, 1851, No. 897,) of a bent spring suspended by its angle and with the two arms tied together by a thread, which thread is to be afterwards burnt and the arms allowed to extend themselves, does obviously contain such a provision, and were it not for the torsion of the suspension wire or thread, might be expected to succeed.

So the device of M. de Tessan, (L'Institut, No. 901, 1851,) viz., a suspended horizontal bar, which while partaking of the rotary motion of the earth, shall by some means be turned end for end, is doubtless correct in principle, since the momentum of each particle of the rod before reversal, would after passing to the opposite side of the vertical, tend to cause the rod to rotate in the opposite direction. But in practice, this momentum would probably be destroyed in passing the vertical, and the experiment prove unsuccessful. A rod suspended by its center of gravity and suddenly let down from a vertical to a horizontal position, would be more likely to succeed—its inertia causing it to maintain when horizontal a constant direction, like the plane of the pendulum. An experiment on this principle was suggested by Lieut. E. B. Hunt at the Albany meeting of the American Scientific Association.

The experiment of M. Bravais, with a conical pendulum, (L'Institut, No. 920, Aug. 20, 1851,) is extremely interesting, and appears to have been entirely successful. He concluded from the nature of the case, that a free pendulum revolving in a circle would perform its gyrations in less time when its motion coincided with the rotary motion of the earth, than when it was contrary to it.

To settle this by experiment, he adopted two distinct methods —that of direct observation, and that of coincidences.

In the first method he observed the time occupied by the same pendulum in making from 900 to 1200 gyrations to the left, and then the duration of the same number of revolutions to the right, the pendulum being 33 feet $5\frac{1}{2}$ inches in length.

The observed times of rotation were as follows.

Right to left.	Left to right.	Diff.
$6^s{\cdot}39887$	$6^s{\cdot}39825$	·00064
6 ·39925	6 ·39849	·00076
6 ·39815	6 ·39751	·00064
6 ·39959	6 ·39863	·00096
6 ·40106	6 ·40032	·00074
6 ·40116	6 ·40044	·00072
Mean diff. - - - -		·00074
The difference by theory is =		·000716

The second method was even more precise. Two pendulums, one slightly longer than the other, were suspended near each other, in the plane of the meridian. One was set revolving to the right, the other to the left simultaneously, and the passage of the threads across the meridian was observed through a telescope, whose optic axis cut the two threads when at rest. Let n and n' denote the number of oscillations of the respective pendulums between two successive coincidencs, $n'=n+1$, n' being the shorter. At the end of the series the pendulums were set revolving in opposite directions respectively, and the recurrence of the coincidences under the new circumstances, determines the numbers N and $N'=N+1$. Let λ=the latitude, T the length of a sidereal day, t the time of a conical oscillation of the long pendulum, separated from the effect of the earth's rotation, and t' the same for the short pendulum. Then we shall have by theory,

$$\frac{\sin\lambda}{T}=\frac{1}{t+t'}\left\{\frac{1}{n+n'}-\frac{1}{N+N'}\right\}.$$

One trial gave $n=207{\cdot}86$; $N=217{\cdot}82$
$n'=208{\cdot}86$; $N'=218{\cdot}82$

Another $n=206{\cdot}31$; $N=215{\cdot}96$
$n'=207{\cdot}31$; $N'=216{\cdot}96$.

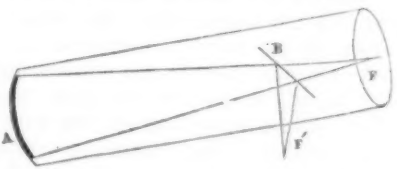
From these numbers the difference in time between a right and left oscillation is found to be, from the first trial, $0^{s}{\cdot}000725$; from the second, $0^{s}{\cdot}000710$.

From these observations M. Bravais concludes that a seconds pendulum, revolving conically, would lose three seconds per day when moving from right to left, and gain the same when moving in the contrary direction. A pendulum 33 feet long would be retarded or accelerated $11^{s}{\cdot}4$ per day. From these observations M. Bravais also computed the length of a simple seconds pendulum, which he made $39^{in}{\cdot}1255$ instead of $39^{in}{\cdot}1291$ the number commonly adopted, ($993^{mm}{\cdot}77$, instead of $993^{mm}{\cdot}86$.)

Art. XLIII.—*Extracts from the Proceedings of the Twenty-first Meeting of the British Association, held at Ipswich, July 2.**

1. *On preparing Speculums for Telescope;* by the Earl of Rosse.

The Earl of Rosse said that, having observed by the public prints that the President of the Association had, in his inaugural address, done him the honor of alluding with approbation to the attempts which he had lately made, and with considerable success, to produce plane speculums of silver for reflecting telescopes,—he thought it might be acceptable to the Section to receive a brief account of them, and he had therefore come down from London that morning to give them such an account. In order to help their conception of what he had to say, he drew with chalk the annexed sketch. A, the great concave speculum at the bottom of the telescope tube, collecting the rays of light which came from a radiant point placed at a great distance beyond the mouth of the tube to its conjugate focus F. These rays were then intercepted by the small mirror B, and by it reflected to the focus F towards the side of the tube where they were received by the eye-piece of the telescope. Now, speaking roughly, it was found that about one-third of all the light which fell upon the great speculum A, was lost in the act of reflection,—and that of the remainder a considerable portion, but not quite one-third, was lost by the second reflexion at B. Of course, since quantity of light is of the utmost importance to the performance of these tubes, this rendered it a matter of the utmost importance either to get rid altogether of the second reflexion at B, or to obtain some means of producing it subject to less loss of light than that caused by speculum metal; and accordingly, Sir William Herschel, the first who had succeeded in producing reflecting telescopes on a large scale, had, by inclining the great mirror slightly, brought the



* From the Athenæum of July 12 and 19, Nos. 1237, 1238.

direct image F to the side of the tube into such a position that it could be received directly in the eye-piece. But it was found that correct images could not be produced in this oblique position by speculums of the ordinary form,—and as yet a means of grinding them to a form that would give correct oblique images had not been successfully devised.

He had received numerous and some most ingenious suggestions for placing the observer in such a position as to view the image F directly at the middle of the tube. One difficulty to be got rid of was, that the head and person of the observer would itself abstract much of the light that should be permitted to proceed to the speculum to be there reflected to form the image. Another was, that the temperature of the body of the observer, so much higher as it was than the surrounding air, tended to produce ascending currents, which both produced a wavering motion and an incorrectness of the image quite fatal to the accurate performance of the instrument. These could, perhaps, be guarded against,—and he had received many most curious and some very ingenious plans for disposing even of the entire body of the observer by lying along in a tube properly and well-ventilated with means for conveying away the breath and heated air out of the telescope tube without interfering with the air in the tube itself. But one element in the problem seemed most strangely to have been overlooked by all, and yet he was bold to say it was the most important of any; he alluded to the diffraction caused by the head of the observer, or by the box or case in which it was proposed to encase it or himself. The effect of this diffraction upon the performance of the instrument would become more injurious also the larger the profile of the object which stopped off the light. Under all these difficulties, he had come to the conclusion that all attempts at viewing the direct image must be abandoned. He then turned his attention to prismatic reflexion, in which comparatively much less light was lost. But he found it impossible to obtain large and sufficiently well-formed prisms to insure the best action. But having obtained a very fine prism of a small size by a distinguished optician, he determined to try it. This required the prism to be placed much nearer to the apex of the cone of light reflected from the great speculum (F), and then the eye-piece required to be of such a form as greatly to diminish the field of view, a matter of the most serious import in the researches of the nebulæ in which he was engaged. This difficulty, however, he had surmounted by first using the larger reflector (B) to examine an extensive field of view, though less perfectly,—and then, by a simple contrivance, turn it aside out of the cone of light, and more minutely examine the limited field of view afforded by the prismatic reflexion. Yet after all, he found this most injurious to the work of making accurate drawings of the appearances.

But another still more serious difficulty is fatal to this mode of reflecting,—namely, that although guided by the research of M. Jamin, and using the formulæ afforded by Cauchy, and every other formula he could conceive or arrive at the knowledge of, both as to polarized light and aberration, he had altogether failed in making this eye-piece achromatic; and if any mathematician of the Section could supply him with the means of securing this result, he would feel himself under great obligations to him, and would cheerfully furnish him with the precise

data of the problem. Under these circumstances, he perceived that there was no resource but to improve metallic plane reflectors as much as possible. Now, it was well known that in reflexion by silver much less light was lost than by any of the other metals,—but, unfortunately, this metal was so soft, that great difficulties presented themselves in giving it the requisite degree of high polish. He had tried by the electrotype process to procure a surface with a high polish by depositing silver on a surface of speculum metal, and treating it by the same process as that used by the distinguished officers engaged in the Trigonometrical Survey of Ireland. But, unfortunately, he soon found that, use what precaution he would, either there took place an adherence of the deposited silver to the surface on which it had been deposited, or the polish was rendered imperfect by the means resorted to to prevent this. He tried copper similarly, which did not adhere, but produced a high degree of polish,—but of course its color and other properties rendered it inadmissible as a reflector. He then determined to endeavor to grind and polish a plane surface of silver, the softness of that metal having heretofore, however, caused the attempt to fail in the hands of the most experienced who had tried it. The processes of grinding and polishing are essentially different: in grinding, the substance, whether emery or other powder, must run loose between the substance which is used to rub it against the other and that which is to be ground; and he soon found that he could not use emery or any other grinding powder for bringing a surface of silver to a correct form,—for, from the softness of the metal and the unequal hardness of its parts, the emery was found to confine its action to the softer parts, leaving the harder portions in elevated ridges and prominences, something in the way that the iron handle of a pump which has been long and much used may be observed to be worn away. Hard steel he found he could bring to a very true surface, and even impart to it a high degree of polish; but the quantity of light it was capable of reflecting was by no means sufficient, nor could he succeed in imparting to the surface of silver by compression with highly-polished steel surfaces the evenly and highly-polished surface requisite for his purpose. At length, he found that he could by the use of good German hones grind surfaces of silver perfectly true, and he had now no doubt that he could with safety recommend for that purpose as the best material the blue variety of the German hone.

The next point was, to polish the surface to a true optical plane reflecting surface. This was by no means so easy a task as may be supposed:—for although our eminent silversmiths do produce surfaces of silver of an extremely brilliant polish, as in the magnificent plateaux and other articles which they turn out, yet if any one will take the trouble to examine these surfaces, they will be found to be so irregular though highly polished, as to be entirely unfit for producing correct images by reflexion. And it is a singular fact that, although in the first part of the process of polishing, chamois leather of the finest kind was used to rub the rouge on the silver surface, yet the finer finishing polish had always to be communicated by the human hand. Nor would the hand of every individual answer:—the manufacturer had to select those with the very softest and finest grain,—nor would the hand of

perhaps one in every twenty of the persons employed answer for thus giving the final finish. But it was obvious that the irregular action of the human hand would by no means answer the end he had in view. Suffice it to say, that at length, after many fruitless trials, he had succeeded in producing a polishing surface which seemed fully to answer the purpose by exposing spirits of turpentine to the continued action of air, or by dissolving a proper quantity of resin in the spirits of turpentine, and by means of this varnish applying the rouge to the same description of polishing substance which he used in polishing the speculum metal, and which he had heretofore so frequently described. By the use of this polishing substance he had produced a plane surface of silver which, as far as the photometric means he had within his reach would enable him to measure the light before and after reflexion, did not lose in that action seven parts of the hundred, and which, tested in the manner which he usually adopted, defined admirably.

The Astronomer Royal begged to know how Lord Rosse secured the plane form of the surface in grinding and polishing. The Earl of Rosse replied that, as to the mode of grinding, it was that commonly adopted for producing accurately flat surfaces. But the mode in which he tested it was peculiar. It was this:—a watch dial was placed before a good telescope, and as soon as the eye-piece was accurately adjusted to the position of most distinct vision, the plane mirror was placed in front of it at an angle of 45°, and the watch-dial was moved round by a simple contrivance to such a position as that its image should very nearly occupy the place it had been just removed from. If now the adjustment of the telescope for distinct vision remained unchanged, the proper form had been attained; but, if by drawing out the eye-piece more distinct vision was obtained, it was concluded it had received a convex form,—if on pushing it farther in it gave the image more distinct, then it was concluded the mirror had received a concave form. Prof. Chevallier wished to know whether Lord Rosse intended to form the great speculum similarly of silver. The Earl of Rosse replied that he had at present no expectation of doing so. That it was a very different matter to grind and polish a speculum of a few square inches surface—which could be done by a small machine worked by hand, and from which to the eye-piece the light had to travel but about three feet—to executing the same operations over the surface of a speculum six feet in diameter, and from which the light after reflexion had to travel a distance of fifty-three feet. For Newton, with his usual sagacity, had long since shown that any error in the form of the object speculum of a reflector was a much more serious injury to the performance of the instrument than an equal error would be in the plane speculum,—and that for the identical reason he had just pointed out.

2. *On a New Method of determining the quantity of Hygrometric Moisture in the Air;* by Dr. Andrews.

In the absence of Dr. Andrews, Prof. Stevelly made this communication. Dr. Andrews had found on trial that several powders when well dried, would rapidly, effectually and completely take up the moisture of damp air passed through them, as effctually as the fused chlorid of calcium, which is too troublesome in the making, preserving

and using for common use. For instance, he had found that well dried oxyd of manganese—and a still more universally obtainable substance, powdered alabaster or sulphate of lime, as dried and prepared by plasterers, or by those who make casts—being inclosed in a small syphon, a measured bulk of air passed through either, at a very quick or at the slowest rate, would be so effectually deprived of all its hygrometric moisture, that another syphon filled with coarser fragments of fused chlorid of calcium gained no weight sensible to a balance which turned with the one-thousandth part of a grain,—the measured portion of damp air being in succession drawn through the syphon containing the alabaster and that containing the fused chlorid of calcium. The apparatus contrived by Dr. Andrews—a drawing of which Prof. Stevelly exhibited and explained—consisted of a gasometer whose bell was attached as a counterpoise to the weight of a Dutch clock sufficiently heavy to work it. By this a measured volume of air was drawn through a tube leading from the open air through the syphon containing the absorbent powder, which was attached to it by collars of caoutchouc, so that after the air had passed through, the syphon could be readily detached, weighed, and the gain of weight by the absorption of the moisture thus determined. In this way he was able in widely various hygrometric states of the air to test the indications of Daniel's and other hygrometers,—to determiue the correct relation between the depression of the wet bulb and the dew point—and even to use the apparatus itself as a simple integrating hygrometer by which the total quantity of vapor contained in a measured volume of air drawn through the apparatus, say during twelve hours, at a uniform rate, may be actually determined by weight.

3. *On the Cause which maintains Bodies in the Spheroidal State, beyond the Sphere of Physico-chemical Activity;* by M. Boutigny.

M. Boutigny referred to his former communications and well known experiments on the peculiar state induced in liquids when in contact with very hot metals, and regretted he had not the means for exhibiting the experiments, as they required apparatus he had not at command in the Section, such as for the application of the spheroidal state of water to the purposes of the steam-engine. He referred to the experiments first shown at Cambridge, and their extension since to explain some of the effects of ancient oracles. Alluding to the disputed points in the explanation of his experiments as to the repulsion of metals and fluids, and whether the effects were entirely or not to be attributed to the properties of the thin stratum of vapor, Prof. Boutigny proceeded to show by experiment that when platinum wire was coiled up in the form of a flat spiral and made hot, and ether or alcohol fluid placed on it, in the spheroidal state, the liquid would not pass through between the spaces, while the vapor readily did so.

A conversation ensued on the subject of M. Boutigny's showing the capability of the human hand to pass through red-hot molten metal without injury; and by the prompt kindness of Messrs. Ransomes & May, the experiment was arranged to take place at 7 o'clock in the evening. Accordingly at that hour the members of the Chemical Section had the opportunity of seeing M. Boutigny pass his hand through

the stream of liquid red-hot iron as it passed from the furnace, and afterwards scooping out portions of iron from the casting ladle, until the fluid sunk to the mere red-hot fluid state, when danger might be apprehended from the falling of the temperature causing the iron to adhere.

4. *On Earthquakes;* by Mr. MALLET.

Mr. Mallet presented his "Second Report on the Facts of Earthquakes," and stated the result of his experiments for the "Determination of the Limits of Earthquake Wave Transit," for which the proposed plan was explained last year. The rate of transit was expected to be the least rapid in sand, and most in some elastic, homogeneous, crystalline rock. Accordingly, a mile was measured on the sands near Dublin, and a cask of powder buried at one extremity,—the interval between the firing of the powder and the indication of the shock at the other station, as registered by Wheatstone's chronograph, gave a rate of 965 feet per second, as the average of ten good experiments. A shorter base was measured on the granite, and shocks produced by borings three and a half inches diameter and eighteen feet deep, in which as much as twenty pounds of powder were exploded. The experiment was repeated twenty or thirty times,—and where the granite was most shattered the shock arrived at the rate of only 1,299 feet per second; under the most favorable circumstances, where the rock was most homogeneous, the impulse travelled at 1,661 feet per second. In many of the most celebrated earthquakes, clocks have been stopped, and thus indications afforded of the rate at which the shocks travelled. In the Lisbon earthquake of 1761, the shock travelled to Corunna at the rate of 1,994 feet, to Cork at the rate of 5,280 feet, and to Santa Cruz in Barbary at 3,261 feet per second. The great Cutch earthquake, in 1819, stopped the clocks in Calcutta, and showed a rate of 1,173 feet per second. The Nepaul earthquake of 1834 stopped numerous chronometers, and the rate of transit from the assumed centre to various places showed a rate varying from 1,000 to 3,000 feet per second. These rates were all lower than would be expected, considering rocks as homogeneous substances; and perhaps, after all, the earthquake shocks might follow a law altogether different from that of *sound* waves.

Mr. Mallet then called attention to the Catalogue of Earthquakes, amounting to nearly 6,000, and—exhibited diagrams in which the amount of earthquake disturbance in all known times was represented by curved lines; these showed a slight indication of paroxysmal periods, with intervals of half a century or more. Another diagram representing the months in which the shocks occurred, showed a maximum in December and January. Mr. Mallet then exhibited a map of the distribution of earthquakes, formed by coloring the area of each successive earthquake recorded in the Catalogue, and one wash of color being carried over another, produced tints of intensity proportioned to the frequency of these visitations. On this map the regions of Guinea, Abyssinia, and Madagascar were uncolored, no recorded earthquakes having occurred in them; Greenland was uncolored, because the slight shocks felt there might have been occasioned simply by movements of masses of ice upon the coast. Special attention was called to one spot

in the Atlantic near the Line, and midway between Guinea and Brazil; vessels passing this tract almost always experienced shocks,—the soundings were extremely variable, some being obtained at 400 fathoms, whilst at very small distances the depth was exceedingly great, as if the bottom was formed by a group of volcanic mountains. The connection between earthquake lines and volcanic lines was very apparent on this map; but some earthquake regions, like Central Siberia and a tract extending from India to Bohemia, display very little volcanic energy. On a diagram section of the globe, the most distant points at which great earthquakes had been felt were connected by straight lines; these showed what very large portions of the mass of the earth might have been affected supposing the original impulses to have been communicated at very great depths. Lastly, Mr. Mallet called attention to the great want of bibliographical catalogues in all public libraries, which rendered the search after earthquake literature a work of enormous labor.

Mr. Hopkins remarked that whilst he placed no faith in such indications as those of earthquakes being more frequent in winter, they were yet very curious; and it was not yet known how much might be due to the influence of apparently trivial causes. With regard to the condition of the interior of the globe, and looking at the earthquake map, he was still disposed to lean towards the hypothesis of the existence of internal lakes of fluid, more or less disconnected, in preference to a fluid central nucleus; earthquake shocks would be propagated to great distances beyond the boundaries of the agitated fluid.

5. *Report on the Physical and Economical Effects of the Destruction of Tropical Forests in British India;* by Dr. H. Cleghorn.

Viewing the question in its physical relations, the author drew attention to the climatic influences of the denudation of the surface of the country; he adverted to the known phenomena of decrease of springs, and the consequent diminution of river supplies, as results of the entire removal of the woods which are collected on the highlands, where such supplies usually originate;—and while distinctly admitting that wherever the wants of an advancing population require the clearance of forest lands, whether for food or the protection of health, such clearance is to be encouraged, he at the same time insisted strongly on the propriety of exercising a careful vigilance, under well defined regulations, in all cases in which the above mentioned causes are not in operation. In considering the economic relations of the question, Dr. Cleghorn availed himself largely of the labors of various distinguished and intelligent observers to illustrate the effects of the existing imperfect system of protection and superintendence. He recorded evidence as to the state of the forests in Malabar, Canara, Mysore, Travancore, the Tenasserim provinces, the Indian Archipelago, and the wooded tracts which skirt the base of the Himalayas. From this evidence, it appears that neither the government nor the community derive from the forests all those advantages which they are calculated to afford. There are numerous products of which the value is known and appreciated,—but which are collected in ways so rude and wasteful, that it is doubtful whether more of them are not lost in the process than are brought

into commerce. There are others, perhaps more numerous, which are known only to the scientific observer; to these, it has been the endeavor of the Committee to direct attention. It is no unauthorized inference, that in the depths of those great forest masses there may still be many substances which only await recognition by instructed eyes to take their places among the valuable agents of manufacturing industry, social comfort, or medical practice. To correct the first, to extend the second, and to discover the third, are the leading points to which the Committee would direct attention; and they have endeavored to furnish to the best of their ability information calculated to advance each of those interesting ends. The general conclusions which appear to the Committee to be warranted by the various statements of fact and opinion, may be summed up as follows:—1. That over large portions of the Indian empire there is at present an almost uncontrolled destruction of the indigenous forests in progress, by the careless habits of the native population. 2. That in Malabar, Tenasserim and Scinde, where supervision is exercised, considerable improvement has already taken place in the forests. 3. That these improvements may be extended by a rigid enforcement of the present regulations, and the enactment of additional provisions of the following character,—viz. careful maintenance of the forests by the plantation of seedlings in the place of mature trees removed,—prohibition of cutting until trees are well grown, with rare and special exceptions for peculiar purposes,—in cases of trees yielding gums, resins or other valuable products, that greater care be taken in tapping or notching the trees, most serious damage at present resulting from neglect in this operation. 4. That special care and attention should be given to the preservation and maintenance of the forests occupying tracts unsuited for culture, whether by reason of altitude or by peculiarities of physical structure. 5. That in a country to which the maintenance of its water supplies is of such extreme importance, the indiscriminate clearance of forests around the localities whence the supplies are derived is greatly to be deprecated. 6. That, since much local ignorance prevails as to the number and nature of valuable forest products, measures should be taken to supply, through the officers in charge, information calculated to diminish such ignorance. 7. That, as much information which may be of practical utility is contained in the manuscript Reports and Proceedings of the late "Plantation Committee," it is desirable that the same should, if practicable, be abstracted and given to the public.

Capt. Strachey said he could not agree with those who thought that forests had much influence on climate. It was a notion that they encouraged rain,—but it was more probable that rain was the cause of forests. He alluded to districts in India in which the forest vegetation was just in proportion to the fall of rain; being small and diminutive where there was little rain, and abundant and gigantic where there was much rain. In temperate climates forests might produce an effect, —but certainly not in the tropics. With regard to the economical question, there could be no doubt that it was foolish to destroy what was valuable, but we had not the power to arrest the present destruction of forests in India. Mr. Bunbury enumerated several instances where forests did not exist and yet there was much rain, and

others where forests existed and there was little rain. Humboldt was our great authority on this subject, and he had recorded his opinions of the influence of forests on climate. In many districts where forests were cleared and single individuals left, these latter soon died from the want of the influence of their neighbors. Dr. Lankester pointed out that according to the laws of vegetation, plants must be supplied with water in a liquid or vaporous form for their growth, and that all the facts which had been mentioned, and which at first sight appeared opposed to each other, might be explained. That forests did not always grow in rainy districts arose probably from the waters accumulating and forming morasses in which forest trees would not grow. In districts where there was not much rain there might be much moisture in the atmosphere,—rain in general supplied only a very small quantity of the water required by plants. Vegetable physiology afforded no explanation of the effects on climate, attributed by some observers to forests.

6. *On the Great Earthquake experienced in Chile, April* 2, 1851, *from* R. Budge, Esq., to W. Bollaert, Esq., *in a letter dated April* 17, *with Observations by the latter.*

"The earthquake came westward and, of course, from the east; which is sufficiently proved from the circumstance of the water in basins, water-jugs, &c., having been spilt over the east side,—from the clocks whose pendulums vibrated east and west having stopped, while those beating north and south did not,—from walls standing east and west being cracked every way, particularly lengthways,—and from vessels at sea, forty to sixty miles off the land, having felt it at a corresponding hour to the difference of longitude. That it is electric I have also grounds for believing; for it is clear to me that in its course it has instantaneously been stayed,—having turned round things on their base, instead of throwing them down, at an angle of 20°, which not only in my own house, but in others have occurred, showing a circular motion for at least an instant. I had a bust of plaster of Paris and a family medicine chest standing on a chest of drawers moved round in this way, while nothing occurred to my house (built, however, purposely on my own plan for resisting earthquakes) except the removal out of place of a few tiles. A large brick chimney, well stayed above with iron stays, was divided at a certain height from the ground in a horizontal line, and the upper part was twisted round over the lower to about the same angle. In some houses which stood firm from being frame built, though cracked in all directions, the furniture in the rooms, particularly up stairs, appeared as if some fiend had been among them, making them his playthings, some upset, some turned round, &c.

I conceive, therefore, now, that since earthquakes are little felt to the eastward of the Cordillera and severally so to the westward, along the whole range, that chain of mountains must be the point of attraction for the electricity of the atmosphere, and that it then follows westward a proper conductor in the earth, finally leaving the earth in the sea,—for how can a ship at sea be shaken as a house on shore, which has been the case, by any other element, for water being capable of compression if driven against a solid frame, as a loaded ship is, will yield to the resistance, and the blow given to the vessel is different altogeth-

er? I have experienced in this place, as I have stated, three ruinous earthquakes,—that of 1822, which I passed in the house until the back fell, that of 1829, and the present; and from observations on each occasion and now again, particularly as in each case I have been calm and resigned, I think I may be allowed to venture my conjecture in common with others, in which I feel so confident that you are at liberty to submit them to your scientific friends if you please, and if any require further particulars I shall be happy to give them. I may, however, add something more;—the barometer and thermometer indicated nothing, nor was there the least warning of any description; but as invariably occurs after a heavy shock, we had on the third day after a shower of twelve hours' rain, for which I had already prepared, aware of its being the consequence, happen at whatever season it may. I conceive, also, that I have felt less relaxed than before it. I cannot understand all these things unless electricity be the agent; while the atmosphere must be affected in some way to shower down rain at seasons when under ordinary circumstances it does not fall. Santiago (the capital of Chile), Casa Blanca, and Quillota seem to have suffered equally with Valparaiso; and the latter two places worse, while some of the public buildings of the capital are ordered to be pulled down. My wife, who is at that place, mentions every subsequent shock tallying exactly with those here. The shock of 1822 was, however, about double in force and time; and I recollect well it was with difficulty I could stand,—whereas on the present occasion I had no trouble. On that occasion, the sea in the Bay of Valparaiso retired considerably, and was several days in reaching its former level,—while on this no such thing was observed. Your newspapers may make out a different story, but you have here at least correct observations. The country is advancing fast; but it is an awful fact to contemplate that the most massive buildings of the country are the first to yield to the phenomena referred to."

The generally received impression is, that earthquakes have their origin in consequence of violent subterranean action, doubtless of a chemical character. Sometimes the violent eruptions of volcanoes are accompanied by severe earthquakes; and in regard to those of Peru I will instance one of this species, in which volcanic action was accompanied by a terrific earthquake, viz., the eruption in February, 1600, in the mountain range of Ornate, twenty-two leagues from Arequipa. On the 15th of that month the volcano broke out with great fury and the ground was in continual motion. On the 18th, in the evening the movements were more rapid, and at 10 P. M. there was such a shock that it awoke the soundest sleepers, and every five minutes during the night shocks continued. On the morning of the 19th occurred a dreadful shock, of which the Spanish MS. from which I extract this says, 'the movements were now more rapid, and in the twenty-four hours there were more than 200 shocks. The heavens were darkened with clouds of eruptive matter, flashes of lightning were seen, and then there descended much white ashes like a fall of snow, which covered the country around.' On the 28th of the same month happened the most dreadful shock of all. The town of Quinistacas, four or five miles distant from the volcano, with 100 inhabitants, was buried; the town of Ornate

also perished; also many villages in the vicinity were ruined; indeed, the whole country was desolated and ashes fell more than ninety miles distant from the volcano.

The first earthquake I experienced was in 1825 and at Chile. There was a shaking of the ground, some houses and walls fell down, and the water in the (arequias or) water-courses splashed over. I was also in that of 1829, being in Santiago. The commotion commenced on Saturday the 26th of September, at twenty minutes past 2 P. M. The principal undulations appeared to come from the southeast. The great shock was one and a half minutes' duration. Half an hour afterwards there was a shower of rain,—and another slight shower at half-past 4 P. M. The weather, however, before the earthquake was rather inclined for rain. During the night of the 26th there were slight shocks; also some on the following days, Sunday and Monday. On Friday the 1st of October, at half-past twelve, there was another shock,—as well as at half-past one. I went out into the street and found the inhabitants looking at two volcanoes that had broken out,—one in the Dehsa, behind the first range of the Cordillera,—the other in the mountains of Maipu (which last was observed to be in activity just after the earthquake of the 26th), the smoke rising majestically. In Peru I have felt many,—but not very heavy earthquakes. In the province of Tarapaca, lat. 20° south, I have noticed them as occurring two or three times a month,—sometimes accompanied by a slight rumbling noise, which appeared to be subterraneous. But on one occasion, being in the silver mines of Guantajaya, a few miles east of the port of Iquique in the province of Tarapaca (these mines are from 2,000 to 3,000 feet above the sea), at about 100 yards perpendicular depth in the mine a slight rumbling noise was heard, as if coming from the Andes, which increased and then passed onwards to the west; the noise was immediately followed by a horizontal undulatory movement, then a vertical, then a mixture of these, or a shake, and then all was quiet, save a commotion occasioned by some of the loose stones of the mine rolling downwards. My impression then was, and still continues, that earthquakes in the region under discussion (Peru and Chile) originate from volcanic causes. A great part of the Andes is volcanic; Chile abounds in active and quiescent volcanoes; and in the province of Tarapaca there are the volcano of Isluga, with its five craters,—the *Volcancitos* or Water Volcanoes of Puchuttisa,—doubtless many quiescent ones,—on its northern boundary the volcanic group of Gualtieri,—and on its southern the volcanoes of Laguna, Olea, &c. Still, the account received from my friend, Mr. Budge, appears so very circumstantial, that I am induced to give his information regarding the late earthquake in Chile *in extenso*.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Laws of Magnetism.*—Tyndal has studied the laws which govern the attraction of an electro-magnet upon a spherical mass of soft iron. The apparatus employed, consisted of an electro-magnet in the form of a straight bar 10 inches in length and $1\frac{1}{4}$ inches in thickness, and wound with 360 feet of copper wire; this magnet was placed vertically under one extremity of the beam of a balance from which was suspended a sphere of soft iron, in such a manner that when the sphere rested upon the end of the magnet, and the copper suspension wire was tense, the balance beam was exactly horizontal. Weights were placed in a scale pan attached to the opposite end of the beam so as to hold the sphere of iron in perfect equilibrium; in this manner the effect of the weight of the sphere was eliminated. The electro-magnet formed part of a circuit comprising also a galvanic battery, a tangent's compass, and a rheostat. In experimenting, a known weight was placed in the scale pan opposite the sphere, and then by means of the rheostat the force of the current, and consequently the attraction of the magnet, was gradually diminished till the sphere separated from the surface of the magnet; at this instant the angular deflection of the needle of the tangent's compass was noted. In this manner the attractive force corresponding to a given intensity of the current is directly expressed by weight. The principal results obtained by the author in this investigation are as follows:

(1.) The mutual attraction between an electro-magnet and a sphere of soft iron in immediate contact with each other, is directly proportional to the force of the magnet or of the magnetizing current.

(2.) If a constant force be applied to the sphere in a direction opposite to that in which the attraction of the magnet is exerted, the attractive force of the latter must vary inversely as the square roots of the distances in order to hold the sphere in equilibrium when its distance from the magnet varies.

(3.) The mutual attraction between a sphere of soft iron and a magnet called into action by a constant current, is inversely as the distance between the sphere and the magnet.

(4.) The mutual attraction between an electro-magnet and a sphere of soft iron, when the two are separated from each other by a determinate distance, is proportional to the square of the induced magnetism. *Pogg. Ann.*, lxxxiii, 1.

2. *Magnetism of Oxygen gas.*—Plücker has given the results of a comparison of the magnetism of oxygen with that of iron. A glass globe was filled with oxygen of the same tension as the surrounding air. The amount of attraction exerted by an electro-magnet upon this globe was then determined by means of a very delicate balance. The globe was then emptied and filled with a solution of chlorid of iron, and the magnetic attraction again determined in the same manner. The attraction upon the oxygen was found to be to that on the solution

as 8·0678 : 1. To determine the attraction exerted under the same circumstances upon soft iron, a glass vessel was filled with a paste made by grinding pure metallic iron in powder (reduced from the oxyd by hydrogen) with a mixture of fresh lard and wax. The amount of attraction upon this glass vessel when empty was first measured, then the attraction upon the same vessel when filled with the solution of chlorid of iron, and finally the attraction upon the glass when filled with the paste of iron. The amount of attraction upon the glass vessel when empty, was subtracted from the amount upon the vessel when filled with the solution and with the paste. In this manner the magnetism of the solution was found to be to that of the iron as 1 : 230·49; the diamagnetic action upon the lard and wax was found to be so slight that it could be entirely neglected. By combining the two numerical results obtained above, Plücker found the specific magnetism of oxygen to be that of iron as 1 : 285·7. If we refer the specific magnetism of the two substances to equivalents instead of to equal weights, we find for the equivalent of iron a degree of magnetism 81·8 as great as that for an equivalent of oxygen. By the same method Plücker found for the magnetism of sesquioxyd of iron the number 891, that of iron being taken as 1,000,000.—*Pogg. Ann.*, lxxxiii, 105.

3. *Molecular structure of organic bases.*—Hofmann has communicated to the Royal Society the second series of his researches, on the constitution of the organic bases—researches of which it is impossible to speak without enthusiasm, and which have thrown a flood of light upon this department of organic chemistry. In a former memoir the author demonstrated that the three equivalents of hydrogen in ammonia are susceptible of being successively replaced by the radicals of the ethyl series ($C_n H_{n+1}$) yielding a new series of ammonias represented by the general formula

$$N(X.Y.Z),$$

in which formula X, Y, and Z, represent either hydrogen or an ethyl radical. The combinations of these new ammonias with acids, may be regarded as *ammoniums* in which one or more equivalents of hydrogen are replaced by methyl, ethyl, &c. Hofmann now finds that the *four* equivalents of hydrogen in ammonium are susceptible of replacement by other radicals, so that the most general formula for a large number of organic bases is

$$N(W.X.Y.Z).$$

The author describes in the present memoir eight new ammoniums in all of which the hydrogen is completely replaced by other radicals.

Iodid of ethyl and triethylamine ($N(C_4 H_5)_3$) heated together for a short time in a sealed glass tube, exhibit a powerful reaction, and on cooling solidify into a crystalline mass easily purified by solution in cold water and recrystallization. These crystals are the iodid of *tetrethylammonium* and are represented by the rational formula $N(C_4 H_5)_4 I$; their formation is expressed by the equation $C_{12} H_{15} N + C_4 H_5 I = C_{16} H_{20} N I$; when rapidly heated they fuse and are decomposed into triethylamine and iodid of ethyl, which again unite in the receiver to form the original compound. The new iodid perfectly withstands the action of a concentrated solution of caustic potash; treated with solutions of the salts of silver, it readily yields iodid of silver and salts

of the oxyd of tetrethylammonium. The oxyd of the new base $N(C_4H_5)_4O$ is easily obtained by digesting the iodid with oxyd of silver in slight excess and filtering, when a clear and colorless solution of the new oxyd passes the filter. As thus prepared the liquid exhibits the strongest analogy to the caustic alkalies potash and soda, it possesses a pungent bitter taste, when concentrated it acts upon the epidermis which it destroys like caustic potash; like this too, it saponifies fats; converts furfuramide into furfurine; decomposes oxalic ether into oxalic acid and alcohol; expels ammonia from its salts even in the cold, and may be substituted for potash in Trommer's well known test for sugar. In its action upon metallic salts the new oxyd is also exactly analogous to caustic potash; it yields however no amalgam corresponding to the well known butyraceous ammonium compound. When evaporated upon the air-pump over sulphuric acid and lime the oxyd may be obtained dry, and even crystallized in long hair-like needles; the dry mass appears to be the hydrate $N(C_4H_5)_4O, HO$ corresponding to the hydrate of potash KO, HO. A concentrated solution of the oxyd of tetrethylammonium is decomposed by boiling, yielding water, triethylamine and olefiant gas, $NC_{16}H_{20}O, HO = NC_{12}H_{15} + C_4H_4 + 2HO$. The salts of the new base are mostly very soluble and even deliquescent; the double chlorid of platinum and tetrethylammonium crystallizes in beautiful octahedrons. The other new ammoniums described by Hofmann are,

(2.) Methylotriethylammonium,	$N.(C_4H_5)_3.C_2H_3$.
(3.) Amylotriethylammonium,	$N.(C_4H_5)_3.C_{10}H_{11}$.
(4.) Methylodiethylamylammonium,	$N.(C_4H_5)_2.C_2H_3.C_{10}H_{11}$.
(5.) Phenylotriethylammonium,	$N.(C_4H_5)_3.C_{12}H_5$.
(6.) Methylethylamylphenylammonium,	$N.C_4H_5.C_2H_3.C_{10}H_{11}.C_{12}H_5$.
(7.) Tetramethylammonium,	$N.(C_2H_3)_4$.
(8.) Tetramylammonium,	$N.(C_{10}H_{11})_4$.

all of which of course exist only in combination; among the products of their decomposition by heat, the author describes several new ammonias or nitryl bases not hitherto considered. The oxyd of tetramylammonium when decomposed by heat yields triamylamine and a volatile hydro-carbon, doubtless amylene; oxyd of tetramethylammonium is also decomposed by heat, but the products of the decomposition have not yet been thoroughly studied: finally the oxyds of the ammoniums (3), (4) and (5), all yield olefiant gas when boiled in concentrated solutions. By the action of the iodids of methyl and ethyl upon conine, nicotine and leucoline, Hofmann has obtained new organic bases, one of which—leucoline in which an equivalent of hydrogen is replaced by an equivalent of methyl—may possibly prove identical with quinine, $C_{18}H_7(C_2H_3)N + 2HO = C_{20}H_{12}NO_2$.

In conclusion the author directs attention to the important theoretical bearings of the new alkaloids. In the first place it is to be observed that the action of the bromids or iodids of the alcohol radicals upon ammonia, give rise to not less than four distinct groups of organic bases; three of these—*ammonias*—are volatile, the fourth—*ammoniums*—

are fixed. The passage from a volatile to a non-volatile organic base may therefore be simply due to the fixation of a single equivalent of a radical capable of replacing hydrogen; and the production of volatile bases by the action of caustic potash upon the fixed alkaloids, quinine, morphine, caffeine, piperine, naturally encourages the attempt to reproduce the latter from the former by simple substitutions. In the next place the new fixed bases lend the most powerful support to the ammonium theory of Ampère and Berzelius; the oxyds of the new bases perfectly correspond to the hypothetical oxyd of ammonium and are stable; again it has always been urged against the theory of Ampère that in the formation of sal-ammoniac for instance, the hydrogen of the HCl could not be reasonably supposed to leave the chlorine for which it has so powerful an affinity in order to convert the ammonia NH_3 into ammonium NH_4; moreover in the action of lime upon sal-ammoniac we must, according to the ammonium theory, suppose that the chlorid NH_4, Cl is first transformed into an oxyd NH_4, O, then this oxyd is resolved into ammonia and water. Now in the action of iodid of ethyl upon triethylamine $N(C_4H_5)_3$ it is perfectly certain that ethyl C_4H_5 actually does leave iodine in order to unite with the triethylamine, and the new iodid readily exchanges its iodine for oxygen when treated with oxyd of silver; finally the new oxyd when heated in solution yields *its* ammonia $N(C_4H_5)_3$ and its radical oxyd C_4H_5O, which is then further decomposed. These two stages of decomposition are precisely those which in the ammonium theory appeared most improbable. Lastly, the mode of formation of the new ammoniums and the products of their decomposition by heat, demonstrate, that whatever be the arrangement of the molecules in ammonia or its congeners, the atoms of the compound rearrange themselves whenever the fourth equivalent of the hydrogen or of its replacing radical joins the compound. Thus the oxyd of amylotriethylammonium $N(C_4H_5)_3C_{10}H_{11}$ yields $N(C_4H_5)_2$. $C_{10}H_{11}$ and C_4H_4, not $N(C_4H_5)_3$ and $C_{10}H_{10}$, clearly showing that an equivalent of ethyl and an equivalent of amyl have exchanged places. —*Philosophical Transactions, Part* 11, *for* 1851.

4. *On Stibmethyl and its compounds.*—Landolt has studied the product of the action of iodid of methyl upon an alloy of potassium and antimony, and has obtained results of great interest and importance. Stibmethyl was prepared by a process precisely analogous to that already employed by Löwig and Schweizer in obtaining Stibethyl, namely, by distilling iodid of methyl with a mixture of antimoniuret of potassium and quartz sand. It is a colorless heavy fluid, possessing a peculiar odor, insoluble in water, soluble with difficulty in alcohol, but readily in ether: in the air it emits thick white fumes, inflames and burns with a white flame, with separation of metallic antimony. Like stibethyl, stibmethyl unites, with oxygen to form a base which saturates two equivalents of acid, and gives compounds with S_2, Cl_2, Br_2, I_2, &c., all of which strongly resemble the corresponding stibethyl compounds. When stibmethyl and iodid of methyl are brought into contact a slight ebullition is noticed, and after a short time the whole solidifies to a perfectly white crystalline mass; these crystals are the iodid of a new radical which the author calls stibmethylium; they are represented by the formula $SbMe_4J$. A similar compound $SbEt_4J$,

is found by mixing stibethyl with iodid of ethyl, and still a third by the action of the iodid of methyl upon stibethyl, Sb Et_3 Me J. In the present memoir the author confines himself to the description of the compounds of stibmethylium. Oxyd of stibmethylium is readily obtained by adding freshly precipitated oxyd of silver to a solution of the iodid Sb Me_4 I, iodid of silver is formed and the oxyd of the new radical set free; the solution evaporated on the air-pump over sulphuric acid, yields a white crystalline mass which is a hydrate of the oxyd. This hydrate exhibits the most surprising resemblance to caustic potash; it gives a slippery feeling when rubbed between the fingers; is extremely caustic; very soluble in water and alcohol, but insoluble in ether; it attracts carbonic acid rapidly from the air and the carbonate formed is decomposed by lime water, the base being again set free. Heated in a glass tube closed at one end, the oxyd gives off vapors which inflame in the air, metallic antimony being set free, but by cautious heating the base may be volatilized unchanged. In its relations to metallic salts the oxyd of stibmethylium agrees perfectly with the alkalies, potash and soda. The author describes further an acid and a neutral sulphate of the new base, a nitrate, carbonate, iodid and chlorid; these are all colorless, crystalline and bitter tasting salts, and are stated—though without measurements—to be isomorphous with the corresponding potash compounds.—*Ann. der Chemie und Pharmacie, April*, lxxviii, 91.

[Note.—The extraordinary analogy which exists between the compounds described by Landolt, and the new ammoniums of Hofmann can scarcely fail to attract the attention of the reader. The parallelism between tetramethylammonium and stibmethylium appears to be complete; the mode of formation of the two is the same; their chemical relations are the same, and the products of their decomposition appear also to be perfectly analogous; thus we have

$$N(C_2H_3)_3 + C_2H_3I = N(C_2H_3)_4I$$
$$Sb(C_2H_3)_3 + C_2H_3I = Sb(C_2H_3)_4I,$$

again we have in the case of the decomposition of $N(C_4H_5)_4O$ by heat

$$N(C_4H_4)_4O = N(C_4H_5)_3 + C_4H_4 + HO,$$

and from Landolt's partial investigation it would appear highly probable that we have under the same circumstances

$$Sb(C_2H_3)_4O = Sb(C_2H_3)_3 + C_2H_2(?) + HO.$$

The isomorphism of Sb $(C_2H_3)_4$ with potassium would be of great interest if proved by careful measurements, and the formation of a new series of alums in which potassium is replaced by N $(C_2H_3)_4$ or Sb $(C_2H_3)_4$, would be a simple and decisive test of this point. It is to be clearly borne in mind that the compounds Sb $(C_4H_5)_3$ and Sb $(C_2H_3)_3$, stibethyl and stibmethyl, although corresponding with ammonia in *formula*, do not do so in chemical relations, since they unite directly with 2 equivalents of oxygen to form basic oxyds saturating 2 equivalents of acid, so that we have Sb $(C_5H_4)_3O_2$ and Sb $(C_2H_3)_3O_2$. It is therefore so much the more worthy of notice that these radicals, when combining with an additional equivalent of methyl or ethyl, yield *ammonium* bases, and Hofmann reasoning in favor of the ammonium theory receives a new support. Landolt's memoir, in several particulars exhibits a want of thoroughness, and the analytical data for

his conclusions are not stated. It would appear however certain that there are at least two classes of ammoniums, nitrogen ammoniums and antimony ammoniums, or N (W. X. Y. Z) and Sb (W. X. Y. Z), and it can hardly be doubted but that the progress of science will make us acquainted with phosphorus, arsenic, and perhaps even bismuth ammoniums, P (W. X. Y. Z), As (W. X. Y. Z), and Bi (W. X. Y. Z).

W. G.]

5. *Selenio-cyanogen and its compounds.*—CROOKER has described a series of salts containing selenium in the same form in which sulphur exists in the sulpho-cyanids. Selenio-cyanid of potassium is obtained by fusing selenium with ferrocyanid of potassium: it crystallizes in needles resembling the sulpho-cyanid is deliquescent and easily decomposed; its formula is $K\,Cy\,Se_2$. With the salts of various metallic bases the selenio-cyanid of potassium gives precipitates; the lead salt is decomposed by HS and yields selenio-cyanhydric acid $H\,Cy\,S_2$ as a strongly acid easily decomposed solution. The other compounds possessed, beyond the fact of their existence, no special interest.—*Ann. der Chemie und Pharmacie*, lxxviii, 177.

6. *Propion.*—MORLEY has described propion or the acetone of propionic acid. Propion is readily obtained by the dry distillation of propionate of baryta, the reaction being expressed by the equation

$$Ba\,C_6\,H_5\,O_4 = BaO.\,CO_2 + C_5\,H_5\,O.$$

It is a colorless or pale yellow liquid, of an agreeable odor, lighter than water with which it is not miscible; it is easily inflamed and burns with a pale blue flame; its boiling point is 100 C., and it is soluble in every proportion in alcohol and ether. With fuming nitric acid propion yields propionic and apparently no other acid.—*Ann. der Chemie*, lxxviii, 187.

7. *Iodid of Nitrogen.*—GLADSTONE has succeeded in determining the true constitution of the so-called iodid of nitrogen and has shown that Bineau's formula NHI_2 is correct. The black powder obtained by the action of ammonia upon an alcoholic solution of iodine, was suspended in water and a current of sulphuretted hydrogen passed through till the solution became colorless and smelt strongly of HS. After gentle heating and filtration, the iodine was determined as iodid of silver, and the ammonium estimated in the usual manner. The ratio of the nitrogen to the iodine in equivalents was found to be as 1 : 2. The same result was obtained by means of the reaction expressed by the equation

$$NHI_2 + 4SO_2 + 4HO = NH_3 + 2HI + 4SO_3$$

the ratios of N, I, and S being found to be 1 : 2 : 4. [It will be remembered that Wurtz obtained an analogous formula with methylamine and iodine, viz. $N(C_2\,H_3)\,I_2$, where methyl replaces hydrogen in NHI_2].—*Ann. der Chemie und Pharmacie*, lxxviii, 234.

8. *Alcohol of caprylic acid.*—BOUIS has prepared what appears to be the alcohol of caprylic acid $C_{16}\,H_{18}\,O_2$, by the action of a concentrated solution of caustic potash upon castor oil; a volatile oil passes over while sebacic acid remains in combination with potash. The reaction is expressed by the equation

$$C_{36}\,H_{34}\,O_6 + 2(KO,\,HO) = C_{30}\,H_{16}\,O_6,\,2KO + C_{16}\,H_{18}\,O_2 + 2H,$$

from which it appears that the decomposition of ricinoleic acid, $C_{36}\,H_{34}$

O_6, is the source of the new alcohol. What becomes of the other constituents of the oil, glyceryl, &c., is not stated. The new alcohol is a transparent oleaginous liquid, having an agreeable aromatic odor; its density is 0·823 at 19° C., it boils without decomposition at 180° C., under a pressure of 760^m. The density of its vapor is 4·49=4 vol. Sulphuric acid dissolves the oil and yields soluble salts of lime and baryta; on heating, the acid transforms the alcohol into a hydro-carbon isomeric with olefiant gas: this carburet is very fluid, lighter than water, burns with a beautiful flame and boils without decomposition at 125° C.: its formula is $C_{16}H_{16}$; the density of its vapor is 3·86=4 vol. Fused chlorid of zinc produces with the new alcohol various isomeric carburets of hydrogen; chlorid of calcium dissolves in it and furnishes beautiful transparent crystals which are again decomposed by water or heat. Acetic and chlorohydric acid transform the alcohol into ethers which have an agreeable aromatic odor; nitric acid when dilute converts the oil wholly into a volatile liquid acid, but the prolonged action of the acid gives pimelic, lipic, succinic and butyric acids. Potash lime at a temperature above 250° C., converts the oil with disengagement of hydrogen into a volatile acid which remains combined with the potash, doubtless $C_{16}H_{16}O_4$. The author promises a more complete study of the new alcohol; the preliminary notice contains much that is obscure and uncertain.—*Comptes Rendus, Aug. 11th*, xxxiii, 141.

9. *On the new metal Donarium.*—In the zircon syenite of Brevig in Norway, Bergemann has discovered a mineral which upon examination proved to contain the oxyd of a new metal, Donarium; the mineral in question is a hydrated silicate of donarium [see p. 387], and is represented by the formula $Do^2O^3SiO^3+2HO$; it is readily decomposed by chlorohydric acid, and after the separation of the silica in the usual manner, ammonia precipitates from the solution a hydrated oxyd of donarium as a white voluminous mass, which upon drying becomes gradually yellowish and reddish yellow. The precipitate contains a little iron from which it is freed by ignition and digestion with chlorohydric acid which dissolves the iron; the oxyd may then be dissolved by long digestion with sulphuric acid; from the sulphate the pure hydrate is obtained by precipitation with ammonia white but becoming yellowish on drying; it is readily soluble in acids; in chlorohydric acid without evolution of chlorine. Metallic donarium was obtained from the oxyd by heating with potassium; the decomposition takes place rapidly with evolution of light, and the metal is separated as a coal-black heavy powder, which under the burnisher assumes a metallic lustre which it retains for several hours even in moist air. Particles of the metal scattered in the flame of a lamp burn with a reddish light to oxyd. Chlorohydric acid hot or cold has no action on the metal; nitric acid acts slowly on heating; nitro-muriatic acid oxydizes it rapidly to red oxyd of which a small portion is dissolved. The anhydrous oxyd obtained by strong ignition of the hydrate is of a very deep red color; its density is 5·576; it is soluble only in sulphuric acid after long digestion and subsequent dilution with much water. The solutions of the hydrated oxyd in nitric and sulphuric acids are colorless; that in hot chlorohydric acid yellow, which color however vanishes upon cooling. Potash, soda, and ammonia, give with solutions of the oxyd white precipitates which are insol-

uble in an excess of the precipitant. Alkaline carbonates yield precipitates soluble in an excess of the precipitant; the solution in carbonate of soda is not precipitated by boiling; that in carbonate of ammonia, on the contrary, is completely precipitated, and the precipitate is not again dissolved in an excess of the carbonate.

Oxalic acid produces in a neutral or acid solution, a thick white precipitate which is insoluble in free oxalic, but soluble in a large excess of chlorohydric acid with the aid of heat. A concentrated solution of sulphate of potash gradually produces a precipitate which is however again dissolved by more water or by HCl. Ferrocyanid of potassium produces in a neutral solution of oxyd of donarium, a nearly flesh colored precipitate soluble in acids. Carbonate of baryta precipitates the oxyd completely in the cold. Sulphid of ammonium produces in solutions of donarium a dark green flocky precipitate which is insoluble in an excess of the precipitate: HCl decomposes it with evolution of sulphydric acid gas. Red ferrocyanid of potassium, tincture of gall-nuts and sulphydric acid produce no precipitate; organic substances, such as tartaric acid, almost entirely prevent the precipitation of the oxyd by caustic alkalies. The oxyd of donarium is not rendered soluble by fusion with caustic or carbonated alkalies; fused with bisulphate of potash, however, a flocky matter is obtained which is soluble in excess of water, and appears to be the double sulphate of donarium and potash. Before the blowpipe the oxyd of donarium exhibits no very characteristic reactions. With soda it forms a globule in which the particles of the oxyd appear undissolved; with borax and the double phosphate it gives a yellowish pearl which becomes colorless on cooling and in which the particles of the oxyd are easily recognized. A mixture of the hydrated oxyd and sugar was ignited and then a current of dry chlorine passed over the mass heated to redness in a glass tube; white vapors were formed which condensed to a voluminous mass perfectly soluble in water, these were doubtless the anhydrous chlorid $Do_2 Cl_3$. The equivalent of donarium was determined by an analysis of the sulphate which gave for the metal 997·4, upon the assumption (which the author considers highly probable) that the oxyd is a sesquioxyd.—*Pogg. Ann.*, lxxxii, 561. W. G.

10. *An Account of an apparatus for producing Attrition between the Surfaces of Siliceous Stones in Vacuo, or in Gaseous Media, and for Determining whether the Consequent Odor and Corruscations are due to Ozonification;* Communicated at a meeting of the Franklin Institute, April 17, 1851, by Dr. Hare, Member of the Institute, Emeritus Professor of Chemistry in the University of Pennsylvania, and Associate of the Smithsonian Institution, (Journal of Franklin Institute).—Dr. Hare submitted to the attention of the meeting, an apparatus for ascertaining whether the phenomena attending the attrition of pieces of silex, when rubbed briskly together, had any thing in common with those ascribed by Schönbein, to a supposed new halogen body, named by him Ozone, and made the following remarks. The odor which results from electrical excitement, or discharges between oppositely electrified bodies, had long been familiar to electricians. This odor is of a nature to recall that of phosphorus to all acquainted with the smell

which this substance has when slowly oxydizing in the air, while to those, unacquainted with the odor of oxydizing phosphorus, the universally known odor of burning sulphur has been cited as an exemplification. Hence, the often repeated allegation of a sulphurous smell being consequent to the passage of lightning. A similar property was likewise observed in oxygen, which had been extricated from water by electrolysis. I observed a like odor about twenty-five years ago, when a large tube, used in the inflammation of explosive mixtures of hydrogen and atmospheric air, was burst by the process; as well as upon other occasions, when similar burstings ensued.

Schönbein, who has attained much celebrity as the inventor of gun cotton, was the first to associate phenomena of the kind alluded to, under one view; and to show that the air which had acquired the odoriferous property in question, however obtained, had certain chemical properties in common. These properties were analogous to those displayed by chlorine, bromine, iodine, fluorine, and cyanogen, which constitute the halogen class of Berzelius; and hence the distinguished investigator conceived that they might be due to some body of that class, which had escaped detection.

To this supposed body he gave the name of "Ozone," from Greek words which signify the production of odor.

As cyanogen is known to consist of two atoms of carbon and one of cyanogen, it would not, *a priori*, be unreasonable that another body should be formed deserving to be ranked in the same class.

Latterly, Schönbein has advanced the idea that ozonification may be owing to a combination consisting of peroxyd of hydrogen and bioxyd of nitrogen, or in other words, of oxygenated water and nitric oxyd. But this inference seems to have been invalidated by an experiment made by de la Rive and Marignac. These distinguished chemists ozonized oxygen by passing electric sparks through the gas, while exclusively occupying a tube in which it had been evolved from chlorate of potassa previously fused, and consequently devoid of moisture.

Hence Berzelius, and other distinguished chemists, deemed it reasonable to ascribe the phenomena to a peculiar state of oxygen.

It had long been known that certain elements were capable of very different states; as for instance, carbon in the forms of tinder, charcoal, anthracite, plumbago, and the diamond.

According to Prof. Draper, chlorine after exposure to the solar rays, becomes more capable of combining with hydrogen under a feeble illumination.

This diversity is displayed in many instances by bodies in what has been called their nascent state, which is assumed just as they escape from combination. Under these circumstances, they will combine with elements for which, usually, they display no affinity. Thus nitrogen, as it exists in the atmosphere, shows no affinity either for carbon or hydrogen, yet when nascent, forms with hydrogen, ammonia, with carbon, cyanogen. On this account I have concurred in opinion with Berzelius, that the phenomena ascribed to ozone may be caused by oxygen in a peculiar state.

It is requisite to mention, that among the tests of the presence of ozonized air, the mixture of starch paste with a solution of iodid of

potassium is the most delicate. This is dependent upon an inexplicable but well known property of starch to be rendered blue by a very minute portion of free iodine. A very small addition of chlorine, by seizing an equivalent portion of potassium, liberates enough iodine to produce blueness in mixture; and, in like manner, a very small proportion of ozonized air, whatever may be its source, renders starch blue by a like procedure.

In like manner, by exposure to ozonified air, strips of paper, drenched with a tincture of gum guaiacum, are rendered blue, as these changes would have resulted from the presence of chlorine, and as neither that nor any other of the known halogen bodies could be present, the agency of some undetected body of that class was reasonably to be inferred.

Having given this preliminary brief sketch of the state of our knowledge respecting ozone, it is time to proceed to explain its connection with the contrivance of the apparatus before us.

It had occurred to me that the smell and corruscations arising from the attrition of siliceous stones, briskly rubbed against each other, might be due to some cause, analogous, if not identical, with that to which the phenomena of ozone are indebted for their existence.

Nothing could be more unaccountable than this odor. That it cannot be due to any organic matter entering into the composition of the quartz must be evident; in the first place, because the smell is produced by the purest and most transparent specimens of rock crystal in the regular form, and in the second place, because ignition to bright redness does not destroy nor even diminish the property.

One thousand grains of cellular horn stone, or French burr, on ignition as above stated, lost five grains—that is to say, one-half per cent. of its weight, without, however, losing the property of producing light and smell.

It occurred to me that it might help to remove the mystery, were an apparatus constructed by which the attrition of siliceous masses might be made more efficaciously than could be effected by an operator unaided by mechanism. Having suggested this idea to my friend, Prof. Henry, he said that I might have such an apparatus constructed at the expense of the Smithsonian Institution. The apparatus, which is before the meeting, was made accordingly.

Two pigmy mill-stones, each seven inches in diameter, made of cellular horn stone, known vulgarly as French burr, and resembling those used in grist mills, were procured and supported as in the usual way, one above the other; excepting that the upper one hangs by means of a bolt upon a spiral spring of brass wire, sustained by a cross of iron, resting upon screw nuts, upheld by four iron rods, each inserted at its lower end in a circular plate of cast iron, so as to be equidistant from each other. The surface of the iron plate is turned true, so as to enable it to serve as an air-pump plate. It rests upon four columns, which elevate it from a base board sufficiently to admit of a pulley band and wheel to work in a parallel plane below that in which the plate is situated. There is also room for a lever, from which a stirrup hangs as a support for the spindle of the pulley, on the apex of which plane extended upwards through a perforation in the axis of the plate, the lower mill-stone rests. This spindle passes through a stuffing box, so as

to be air-tight; the stirrup allowing it to retain its perpendicularity, notwithstanding the curvilinear movement of the lever when employed to raise or lower the stone.

The nuts upon which the cross supporting the upper stone has been mentioned as resting, are so used as to render the lower surface of the stone horizontal, while, as it hangs upon a bolt which occupies the axis of the spiral spring, the pressure on the lower stone, when brought into contact with it, may be made as gentle as necessary. The lower stone being balanced on the point of the spindle, is made to turn with it by means of a pin proceeding from its lower surface and another proceeding from the spindle, which operates as a carrier in a lathe.

In order to put the apparatus in operation, the lower stone is made to revolve by means of the pulley, band, and wheel; while, by means of the lever, the stone is so raised as to produce sufficient contact with that suspended above it. Under these circumstances, scintillation and the odor which is the object of inquiry resulted. In no way, however, could I produce the chemical effects of ozone upon iodized starch or guaiacum. On directing a jet of hydrogen between the stones, it took fire forthwith; but I could not, by means of an electrometer, detect any electricity. When the upper stone was removed, and a piece of an old file of a large size made to scrape over the surface of the lower stone, a conducting connexion between the file and an electrometer was productive of no electrical indication.

The plate being ground to fit a large receiver, the stones were in successive experiments made to revolve in vacuo, in hydrogen, and in a vacuity previously replete with this gas, without any diminution of the luminous phenomena. These, it seems from the inflammation of the jet of hydrogen, constitute a simple case of ignition. During the collision of flint with steel, a portion of the metal being struck off, takes fire, and thus is enabled to convey ignition to tinder or punk. The incapacity of two pieces of quartz to produce fire in like manner, arises from the incombustibility of the particles struck off from them, which consequently cool before they meet any mass with which they are not in contact at the moment when the ignition supervenes.

As the burr stones are opaque, the light is much less advantageously seen when they are both employed, than when the upper one is replaced by a comparatively small mass of transparent quartz. The concentration of the frictional force, and the transparency of the mass under which the ignition is effected, makes the corruscations very brilliant in a room otherwise darkened.

So great is the resistance of the surfaces of the stones when brought into revolutionary collision, that the maximum effect which they are capable of producing, would require more force than can be communicated by the human power, through a single hand actuating the stones by means of a wheel, pulley, and band.

Of course cog wheels might be resorted to, and the power of steam or that of Professor Page's electro-magnetic machine, employed to obtain a greater effect. I have lately been informed, that in English potteries where flint is employed as an ingredient in the ware manufactured, the grinding of this material is productive of an intolerable fœtidity. In an atmosphere thus imbued with fœtidity, chemical effects ought to

be observable if there be any connexion between the source of this fœtidity and that produced by ozonizing agents.

It is long since it occurred to me, that as the phenomena of light, under all the various hues which it is capable of producing, are ascribed to the undulatory affections of an ether pervading the universe; so the still greater variety of odors which influence our olfactory nerves, may be due to vibratory agitation of the same medium.

Consistently it may be conceived that the odor produced during ozonification, during the attrition of quartz, is due to an odoriferous etherial agitation.

II. Botany and Zoology.

1. *Note on the Vegetation of the Coal Period;* by Mr. J. E. Teschemacher, (communicated for this Journal.)—In 1843 my attention was first attracted to the remains of vegetables in the anthracite coal from Pennsylvania; by the year 1846 my collection of specimens was very numerous, and in 1847 I exhibited a small portion of them before the American Society for the Advancement of Science, at their annual meeting in Boston.

In 1846, the Natural Hist. Soc. of Haarlem, in Holland, adjudged a prize to Dr. H. R. Gœppert, professor in the University of Breslau, for a most elaborate and well written dissertation in reply to the prize question proposed by them,

"Whether the beds of coal were composed of plants which grew on the spots where these coal beds now exist, or whether the vegetation grew in other places, and was floated or brought there by other means."

This dissertation, with between 30 and 40 plates, was published at Haarlem in 1848, and has been recently added to the library of the Nat. Hist. Soc. of Boston, from the funds left by James Lloyd which were in the possession of the Republican Institution, and were generously devoted by the members, to the diffusion of science, by the presentation thereof to the Nat. Hist. Soc. for the purchase of the most recent sterling works in its several departments.

From this masterly dissertation it appears that Dr. Gœppert, for the purpose of elucidating this subject, had been pursuing the same course with the coal from various beds in Germany, as I had with those of Pennsylvania. And although the main question has received the same solution from both, namely, that the plants grew where the beds of coal now exist, and were solidified amongst other conditions under that of absolute rest, yet upon some minor points we differ, and I believe that the extent of the beds from which my specimens have been taken, has afforded much more varied appearances than have as yet met his eye.

I should not attempt by any discussion at present to alter the views of Dr. Gœppert, unless I could exhibit to him my specimens, for many of my impressions were at first nearly the same as those he has expressed; and it was only by the reiterated and close examinations of fresh specimens that I was led step by step to change my opinions. In fact, without the inspection of regular series of specimens, presenting various details, it is impossible to arrive at satisfactory conclusions on many points of this occult subject, and it has several times occurred that a

single specimen has thrown unexpected light, not obtained by the inspection of fifty others of nearly the same appearance.

As it is, the questions in doubt are much more numerous than those which appear settled. One of the characters which seems to have escaped him is that of the fissures chiefly traversing well defined vegetable surfaces (epidermis). These are from $\frac{1}{8}$ line to $\frac{1}{4}$ inch in depth, describe various curves, or right lines, sometimes parallel lines, and forms of all kinds, they are sometimes filled with siliceous matter and sometimes with a charcoaly mass evidently of different structure to all around. Neither does he seem aware of the *numerous* fossil remains of fungi in the coal, some of these much resembling those which now exist in the siliceous epidermis of the bamboo and the rattan.

I also differ from him in what he considers the annual rings of Araucaria, although my first impressions were similar to his.

My specimens of Sigillaria, Lepidodendra, and Sagenaria are numerous, and there are various appearances, resembling the internal structure of some of these gigantic vegetables, which if they can be recognized as such would cause considerable astonishment. The appearances which Dr. Gœppert has at present probably no idea of, are many and very interesting, but without well and carefully drawn figures, descriptions of them, would be useless. In stating that I differ from so experienced a naturalist on this subject as the learned professor of Breslau, it is far from my intention to impute to him even erroneous views—yet it is only from difference of opinion that truth comes to light, and this is my only desire.

When this subject shall have been taken up and studied by scientific men whose minds are well prepared and who are possessed of sufficient leisure, I am sure that extremely interesting facts and consequences will be developed by their observations.

Boston, Sept. 13th, 1851.

2. *Conspectus Crustaceorum, &c.; Crustacea of the Exploring Expedition;* by James D. Dana.—Crustacea Grapsoidea, (Proc. Nat. Sci., Philad., 1851, p. 247.)—This paper includes descriptions of the following new species :*

Eucrate crassimanus; Macrophthalmus pacificus; Gelasimus nitidus; Helœcius inornatus; Pseudograpsus oregonensis, P. nudus: Grapsus planifrons, G. longitarsis, G. crinipes; Goniograpsus simplex, G. innotatus; Planes cyaneus; Hemigrapsus crassimanus, H. affinis; Cyrtograpsus angulatus; Sesarma obtusifrons, S. obesum; Sarmatium crassum; Cyclograpsus cinereus, C. granulatus; Chasmagnathus subquadratus, C. granulatus, C. lævis; Helice crassa; Acanthopus abbreviatus; Plagusia speciosa, P. glabra; Cardisoma obesum, C. hirtipes; Pinnothera faba; Fabia subquadrata; Halicarcinus pubescens; Hymenicus varius, H. Novi-Zenlandiæ, H. pubescens.

2. *Mastodon in Northern Illinois;* by Prof. S. P. Lathrop.—A large tooth of a mastodon in a fine state of preservation has recently been found in the Kishwaukee river, in New Mifford Co., Illinois. It was drawn up by a seine, from near the mouth of the river.

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* For the genera see this volume, page 283.

III. Miscellaneous Intelligence.

1. *Great Exhibition in London.*—The scientific portion of the great exhibition though falling far short of the reasonable expectations of men of science, presents yet many objects of interest and I have thought that a few notes taken upon the spot might prove useful if only as hints to those wishing to purchase apparatus abroad. Of a liberal display of balances for chemical and physical purposes, we have to notice the instruments of Messrs. Deleuil and Collot in Paris, of A. Oertling in Berlin, L. Oertling in London, and the United States balances of Mr. Saxton. Deleuil* exhibits balances of three sizes; the largest or balance for physical researches is intended to bear as much as two kilogrammes in each scale and with this load will turn with one milligramme; it is mounted upon a cast iron base and placed within a large case with glass doors, so that bulky objects, as glass globes, &c., may be conveniently weighed. When the beam rests upon its supports, the pans are also supported separately; in throwing the beam off its support the pans are suspended, their knife edges resting upon agate planes: the index is placed in the centre of the beam and descends to a scale below. The workmanship of the whole instrument is admirable; its price with weights is 1500 francs. The large balances of MM. Collot frères, are very similar to those of Deleuil, differing chiefly in having a glass base instead of one of cast iron. Deleuil's smaller balances for chemical purposes when loaded with 200 or 300 grm., are sensible to half a milligramme; the beam as in the other instrument is of brass; the pans are of platinum suspended by silver wires; they are not suspended from knife edges, but by means of steel hooks resting in stirrups upon the end of the beam, an arrangement which is certainly objectionable. The beam in these balances is divided for a sliding weight but there is no sliding rod as in Oertling's instruments. The assay balances by the same maker deserve the highest praise for workmanship and elegance of construction, they are of steel with an index pointing vertically upward; the whole is admirably arranged and of exquisite finish. A. Oertling of Berlin exhibits also both chemical and physical balances; the former are too well known and too generally appreciated in this country to require special notice; the larger instruments will weigh from one kilogramme to one-half milligramme; their construction is upon the whole similar to that of the chemical balances, the beam being divided and furnished with a sliding rod and weight. There are however two indices or pointers instead of one placed horizontally, one at each end of the beam and each is furnished with an index scale. This arrangement is perhaps advantageous for very large balances where a slight deflection of the beam might occur, but it appears unnecessary and is certainly inconvenient in smaller instruments like those employed in delicate physical investigations. The division upon the beam and the use of a sliding weight appears also unadvisable in balances of this size with which it is rarely necessary to weigh very rapidly, but the principal and serious objection to the construction of Oertling's larger balance lies in the suspension of the pans, which rest

* Deleuil, 8 Rue du pont de Lodi.

constantly upon their knife edges when the beam is resting upon its supports. On the whole, therefore, while doing full justice to the admirable workmanship of Oertling's instrument we must give the preference to Deleuil's larger balance for *physical* investigations, regarding always the smaller balances of Oertling's as superior to all others intended for chemical researches. Of the English balances the only one worth noticing is that of L. Oertling of London; the beam of this instrument is very light and the instrument would appear to be a good one, but its shape is inelegant and the want of the sliding rod arrangement is a serious inconvenience. The Danish, Swedish and Belgian balances do not deserve notice; the superintendent of the U. S. Coast Survey exhibits two balances by Mr. Saxton, a larger and a smaller, but the construction of these is too well known in this country to require description at our hands; they are at least equal in point of workmanship to any which the writer has seen abroad.

Of optical apparatus the display in the exhibition is upon the whole very good. M. Duboscq,* son-in-law and successor of Soleil, exhibits a very fine collection of optical instruments, among which we noticed as of recent introduction, Duboscq's regulator of the electric light, and Jamin's instrument for the study of the phenomena of reflection at transparent surfaces. The Nicol's prisms, rhombs and spheres of iceland spar, and glass prisms executed by Bertrand,† are the finest specimens of workmanship in this department which we have ever witnessed. Of glasses for optical purposes there are many interesting specimens. Messrs. Chance of Birmingham exhibit discs of flint glass eighteen, and of crown glass twenty-four inches in diameter; the flint discs appeared to be of fair quality, but we had no opportunity of examining them closely as to veins and striæ; the crown glass was of bad color, indicating want of purity in the materials. The new French glasses with bases of zinc and baryta are admirable, and of perfect transparency and high refractive power; the discs for optical purposes though not so large as the English ones were of perfect quality, and an opportunity of examining them closely was freely given. Several discs, and prisms of flint glass from T. Daguet of Soleure in Switzerland also deserve notice. The only thermometers and barometers adapted for scientific investigation were those of Fastré;‡ the thermometers are constructed in exact accordance with the method of Regnault, being furnished with arbitrary scales and divided upon the stems themselves: the barometers are constructed nearly upon the plan of Fortui. In connection with these instruments we may mention the straight line dividing engine of Perreaux,§ now generally used in the French physical laboratories. Of these there are two sizes, one for the graduation of lines not exceeding 70 centimeters in length, (price with microscopes for revision 900 fr.) the other for lines not exceeding 45 centimeters, (with microscopes 500 fr., without them 400 fr.) Of the very large number of electric telegraphs exhibited, there were we believe none which employed principles essentially different

* Duboscq, Rue de l'Odeon, 35.
† Bertrand, Jr., 32 Rue de Bretagne.
‡ Fastré, Rue de l'ecole Polytechnique, 3.
§ Perreaux, Rue M. Leprince, 14. Paris.

from those now generally known or at all likely to replace the modes of telegraphing employed in this country.

In the departments of electricity and magnetism the instruments of purely scientific interest were rare; we have to notice only a Weber's electro-dynamometer by Leyser of Leipsig, and very powerful steel magnets by Logeman of Haarlem. Schrœder of Darmstadt exhibits a large and admirably executed set of models of crystals in wood; Engel of Berlin has a very beautifully constructed hollow wooden model of the wave surface in biaxial crystals; Nobert of Greisswald, the well known microscope maker, exhibits sets of his ruled glass test plates for microscopes. The philosophical apparatus in the English department is mostly intended for the illustration of lectures, and possesses very little merit even for its purpose. Of apparatus for scientific research there is almost none, if we except the microscopes of Ross and other well known makers. There is however in the English department a considerable display of astronomical instruments, constructed chiefly upon the principle that such instruments are good in proportion to their weight, and not likely to be adopted by those who are acquainted with the works of the German artist mechanicians. The purely chemical portion of the exhibition is almost wholly without objects of interest. There are of course a great number of finely crystallized specimens of alum, bichromate of potash and other showy salts, but these are remarkable only as illustrating the scale upon which their manufacture is carried on. Of photographic pictures there are a countless number upon silver, paper and glass; the American daguerrotype portraits are far superior to any others, but the photographs upon paper exhibited in the French department, especially those of Martens, are beyond comparison the finest specimens of the art; the pictures executed upon glass possess a remarkable softness and richness as well as sharpness of outline. It is to be hoped that this branch of photography will soon receive attention in this country. W. G.

2. *Aurora Borealis.*—Since the grand aurora of November 17th, 1848, (which was distinguished for its great extent, being seen in nearly equal splendor from Odessa on the east to California on the west,) we have had no exhibition of this phenomenon of the highest class, like those which occurred from 1835 to 1839, inclusive; but the late month of September has been signalized by three grand auroras, occurring respectively on the nights of the 3d, the 6th and the 29th. An aurora borealis of the highest class, is distinguished by the presence of all the more striking characters of the phenomenon combined, or at least exhibited in rapid succession, such as arches, streamers, a corona, and waves. Each of the late auroras was characterized by marks of the greatest intensity, especially in the completeness and grandeur of the *corona*, and of *auroral waves;* and that of the 29th was remarkable for passing to a great distance beyond our zenith, presenting a well defined and very luminous arch, whose point of culmination was within 30° of the southern horizon. Below this appeared a dark slaty segment, probably the effect of contrast, since the stars shone upon this black ground with unusual brightness. What is quite unusual, this meteor was visible throughout the southern states, and presented a striking and splendid appearance as far south as Charleston and Savannah.

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3. *On the Earthquake in Calabria;* by E. J. MORRIS, (letter to editors of Washington Republic, dated Naples, Aug. 26, 1851.)—On the 14th ult., the western portion of the continental part of this kingdom, from the northern confines of Calabria to the Roman frontier, was agitated by several calamitous shocks of earthquake. This convulsion appears to have had its origin in the volcanic region of Mount Vulture, about one hundred miles to the southeast of Naples. It is a detached and isolated eminence, three thousand feet in elevation, rising at the point where the Appenine chain terminates on the borders of the Basilicata and Apulia; its slopes and summits are broken into numerous craters, of the action of which no record exists, but which yet bear undoubted evidence of eruptive violence at some remote period.

The city of Melfi, separated from Mount Vulture by a deep ravine, is built upon the summit of a hill, the composition of which is grey lava, intersected by strata of travertine upon layers of ashes, sand, tufa, and decomposed stalactites, all denoting the site of an extinct or dormant volcano. Previous to the first shock, a small stream which runs near the town suddenly disappeared, and the shepherds on the mountain were alarmed by loud rumbling noises beneath their feet. The monks of an adjoining convent, admonished by these phenomena, escaped from their building almost at the moment it was rent in twain.

At the first shock, Melfi, which contains ten thousand inhabitants, was prostrated in the dust, nothing but a few crumbling walls surviving the general ruin. An unknown number of its inhabitants were buried under the falling mass of fabrics; up to the present moment seven hundred dead bodies have been disinterred and others are constantly being found; more than two hundred persons lie in an adjacent hospital, suffering under grievous wounds, while many have been dug out alive from the ruins. Amongst others, a female infant a year old, after lying buried for two days, was brought out living and unharmed, and restored to its afflicted mother, widowed by this same calamity.

The neighboring towns of Atella, Rionero, Barile, and Rapolla, are sufferers by the same convulsion. Rionero is a general wreck, not a sound house remaining—more than a hundred persons have here perished, and as many have been maimed or wounded. In Barile, the only edifice not entirely destroyed is the orphan asylum, while the discovered dead amount to about one hundred and fifty. In the commune of Bari, the towns of Cerato, Minervino, Spinnazzola, Andria and Trani, were all more or less injured. In Canosa, the ancient Canosium, founded by Diomed, and whose walls once enclosed a circuit of sixteen miles, three hundred and seventy-six houses were thrown down. At the last reports the shocks around Mount Vulture continued, and one-half of the city of Venosa, the ancient Venusia, containing six thousand inhabitants, and celebrated as the birthplace of Horace, was destroyed. The mountain provinces of the Abruzzi and of Calabria, where the earthquake of 1783 destroyed three hundred cities and buried thirty thousand human beings, have thus far escaped.

The recent earthquake commenced with a sharp concussion, which was succeeded by an undulatory movement, the first shock being about sixty seconds in duration. At Melfi there were six shocks, the first at $5\frac{1}{4}$ P. M., the second at $3\frac{1}{4}$, the third at $4\frac{1}{4}$, the fourth at 10 P. M., the

fifth at 3 A. M., and the sixth at 7 A. M. At my summer residence in the country, eighty miles from Melfi, the house shook to its foundation, and such was the vibration, that it was difficult to descend the staircase. For ten minutes previous the house dog howled in most dismal tones, the chickens cackled and hurried about as if fleeing from some anticipated danger, and a pair of turkeys rose in the air and flew around the house screaming as if seized by a secret terror, while all the dogs in the neighborhood were in full bay. No damage was done at La Cava, or at Naples, beyond slight cracks in old walls. * * *

The loss of life from the earthquake of the 14th ult., it is supposed will amount to more than two thousand five hundred souls.

3. *Palæontographical Society.*—This Society was established in 1847, for the publication of works on British fossils, for the benefit of its members. A subscription of one guinea a year is required for membership, and the addition of names is solicited, as the amount of the publications per year depend on the income. The works thus far published are in 4to., and at the ordinary cost of similar publications could not be obtained at four times the amount which members actually pay. The engravings are in the highest style of the art, and the memoirs are all from authors of established reputation. The publications began in 1848, and are as follows:—

Monograph of the Crag Mollusca, or Descriptions of Shells from the middle and upper tertiary of the East of England; by S. V. Wood, F.G.S. Part I. Univalves; 208 pp., with 21 plates. Part II. Bivalves; 150 pp., with 12 plates.

Monograph of the Entomostraca of the Cretaceous Formation of England, by T. Rupert Jones, Esq.; 37 pp., with 7 plates.—A monograph of the Permian fossils of England, by Wm. King; xxxviii and 258 pp., with 28 plates.

Monograph of the Fossil Reptilia of the London Clay; Part I. Chelonia, by Professors Owen and Bell; 78 pp., with 28 plates. Part II. Crocodilia and Ophidia, by Prof. Owen; 68 pp. with 16 plates. Part III. Fossil Reptilia of the cretaceous formations, by Prof. Owen; 118 pp., with 37 plates.

The Eocene Mollusca, by Frederick E. Edwards. Part I. Cephalopoda; 58 pp., with 9 plates.

Monograph of British Fossil Corals, by H. Milne Edwards and Jules Haime. First Part: Corals of the Tertiary and Cretaceous Formations; lxxxvi and 72 pp., with 11 plates. Second Part: Corals of the Oolitic Formations; 75 pp., with 19 plates.

Monograph of the Mollusca from the Great Oolite, chiefly from Minchinhamptin and the coast of Yorkshire; by J. Morris and John Lycett. Part I. Univalves; 130 pp., with 15 plates.

Monograph of British Oolitic and Liasic Brachiopoda, by Thomas Davidson; 64 pp., with 13 plates.

Monograph of the Fossil Lepadidæ or Pedunculated Cirripeds of Great Britain, by Chas. Darwin; 88 pp., with 5 plates.

Sir H. T. De la Beche is President of the Society. Persons wishing to subscribe, may address Searles Wood, Esq., Fortess Terrace, Kentish Town, England. Payment in advance is required.

4. *Dr. Krantz's Geological and Mineralogical Specimens.*—The writer, in company with the senior editor of this Journal, had an opportunity lately of examining the arrangements of Dr. Krantz's establishment for the sale of mineralogical and geological specimens, at Bonn on the Rhine. Dr. Krantz was induced to remove his collections from Berlin in consequence of the greater facilities in his present position, both for collecting and transmitting specimens. He has built a spacious house expressly for the accommodation of his business, and he merits the high reputation, which he already enjoys, for accuracy, integrity and zeal, in the department of science in which he is prepared to meet the wants of the scientific community. The highest confidence may be placed in both the names and localities of the species leaving his establishment. The geological series is peculiarly full and rich in American fossils from the older rocks, collected mostly under the personal supervision of Mr. Seamann, his highly intelligent voyageur who was in the United States in 1849—and who is now specially devoted to the geological department. It is rather singular, but we believe it is true, that it is easier now to get a good series of American fossils from Bonn, than to collect them in America, and certainly it may be done at less cost. Dr. Krantz's mineral cabinet, (his private one,) is one of the best in Europe, as it has been made up from the choicest selections of many years of active collection and exchange. It extends to over 6000 specimens and embraces fine examples of many of the rarest species. We cordially recommend Dr. Krantz's establishment to our friends as the best with which we are acquainted in Europe, for the sale and purchase of specimens. See his advertisement in detail in our advertising pages.

5. *Gold in Australia.*—Gold has been discovered, in the Blue Mountains of Australia, in the vicinity of Bathurst. It is said to be abundant, and many large masses have been found. One of eight pounds has been reported.

6. *Prize offered by the Royal Prussian Academy at Berlin.*—A prize of a hundred ducats is offered for the best work on the nature and mode of action, and resulting constitution, of hydraulic mortar, including the constitution of zeolites generally, but especially of those produced in the solidification of mortar.* The time allowed is till the 1st of March, 1854. The manuscript is to be either in German, Latin or French, and to include the name of the author. The prize will be adjudged "in conventu solemni Leibnitiano," which is held in the month of July, 1854.

OBITUARY.

Lorenz Oken, Professor of Natural History at the University of Zurich. He is well known for his views on the philosophy of nature, which are throughout profound; yet while partly exhibiting, as in his ideas on homology, a deep insight into the harmony of nature, even in ad-

* The following is from the announcement:—"Mortarii hydraulici quamquam natura jam magna ex parte perspecta est, continetur enim haud dubie formatione silicatorum ζεολιθωδῶν: restat tamen, ut chemica earum, quæ ex mortarii speciebus adhibitis oriuntur, conjunctionum ratio accuratius cognoscatur. Postulat igitur academia, ut universum hoc genus diligenter pertractetur, imprimis autem in earum, quæ ex mortario gignuntur, conjunctionum formationem methodis commodis inquiratur."

vance of discovery, they are partly mystical, and widely at variance with the system of existences around us.

Alexander de Saluzzo, President of the Academy of Sciences at Turin.

Mr. William Nicol, the inventor of the single image prism of calcareous spar, known as Nicol's prism, and a frequent contributor to the Philosophical Journal. His age at death was 83 years.

Baron de Silvestre, at Paris in his 89th year. He was one of the founders of the Philomathic Society, a member of the Academy of Sciences, and Perpetual Honorary Secretary of the Central National Society of Agriculture, of the list of whose members at its foundation, he was the sole survivor.

Dr. König, for many years in charge of the Mineralogical Department in the British Museum. He died suddenly in August last.

IV. Bibliography.

1. *United States Exploring Expedition during the years* 1838–1842, *under the command of Charles Wilkes, U. S. N.* vol. xi.—*Meterology*, by Charles Wilkes, U. S. N., with 25 illustrations. Philadelphia, 1851.—This volume consists of a series of tables containing the meteorological observations made in the course of the cruise of the Expedition, preceded by an introductory chapter of 58 pages, treating of the general results, and illustrated by colored plates. On these plates, diagrams representing the track of the vessel, the changes in the temperature of the air on deck and at mast head, of the ocean, and of the barometric pressure, are given for the whole course of the cruise: and as the different lines are colored, the facts are brought out with unusual distinctness, and are convenient for comparison and study.

As the cruise occupied nearly four years, and extended over all the oceans of the globe except the Arctic, it is evident that the observations have no small interest. We have space to cite only the following from among the facts here registered. On Mauna Loa, at a height of 13,440 feet, the wind, for the most of the time passed at the summit, blew from the southwest, while it was from the north and northeast at Hilo, at the eastern foot of the mountains. All the gales experienced, seven in number, occurred at night, being most violent between the hours of 11 P. M. and 4 A. M.: only one of these gales was felt at Honolulu on Oahu to the west, while at Hilo none was experienced. Clouds were seldom seen above the height of 8000 feet, except during stormy weather; the vapor plane, or height at which the clouds usually remained, was about 5000 feet above the sea level. The sky instead of having the blackness spoken of by some travellers appeared of a beautiful blue. One of the most striking phenomena observed was the shadow of the mountain thrown at sunset on the eastern sky, looking like an immense dome bounded by an outline of a light amethystine tint, and deepening to a dark purple towards the center.

In the remarks on the barometric observations, it is observed that the results show a general depression within the tropics, a bulging in the temperate zone, and again a depression on advancing towards the Arctic and Antartic circles.

2. *Outlines of Chemistry for the use of Students;* by Wm. Gregory, M.D. First American from the second London edition, by J. M. Sanders, M.D., LL.D. 12mo, pp. 614. Cincinnati. 1851: H. W. Derby & Co.—Dr. Gregory's outlines of organic chemistry, embracing the views of Liebig was extensively read, by chemists in this country, at the time of its publication, as the most compendious view of the condition of organic chemistry at that time accessible in the English tongue. That work is here reproduced by its author in an improved form and in connection with the inorganic chemistry now added, forms a very convenient and useful book, both for the student and teacher. Dr. Sanders's edition is a reprint from the London issue of 1847, very neatly done and with general accuracy. The peculiarity of Dr. Gregory's work compared with most chemical treatises in our language, is the omission of all reference to the general powers of matter commonly called the 'imponderables.' The book is strictly what its title implies, and the student is supposed to derive his knowledge of physics as he does his mathematics and zoology entirely from other sources. Undoubtedly this is quite the correct course for the teacher of chemistry, and coincides, probably, with the sentiments of most lecturers on this subject. But unfortunately, and especially in America, it is rarely, indeed never, safe in a mixed class such as compose the medical schools in this country, to presume on the possession of such physical knowledge as is commonly imparted in the preliminary lectures of a chemical course. In fact, heat is a subject so closely connected with chemistry, and so dependent on a knowledge of molecular chemistry for its elucidation, that it is difficult to present either subject disconnected from the other. Nevertheless we are happy to have so good a book as Dr. Gregory's, accessible to chemical students in America, and have no doubt that it will be very useful and acceptable.

3. *Catalogue of Shells contained in the collection of Dr. John C. Jay.* Fourth edition, 4to. Dec., 1850.—The extensive collection of Dr. Jay, and his equally extensive conchological library, have for many years been well known to those who have made this science their special study; and they unitedly present advantages, which as yet are furnished by no public institution in our country.

The catalogue of a collection which M. Deshayes has declared "would, even in Europe, be considered one of the first rank," must possess interest to every student of natural history. The new and enlarged edition before us, is the largest printed Catalogue of recent shells ever published, enumerating about eleven thousand well marked varieties, and comprehending at least seven thousand well establshed species.

The value of the work however, is imperfectly indicated by its unassuming title, for it has far other merits than those of a mere catalogue. To every species is added not only its authorship and habitat, but also a complete synonymy, with references to all the good descriptions and figures extant. These references have all been carefully verified, which alone is a work of great labor, as they number about *eighteen thousand.* Every synonyme of any species (whether or not generally adopted) is found in its proper alphabetical place, followed by a reference to its received name. For instance, the student who is in doubt about *Helix*

radiata, Fer., turns to it at its proper alphabetical place in the genus *Helix*, and is there told that it is now known as *Bulimus detritus*, Müller. For this he searches in the genus *Bulimus*, and there finds it enumerated, with its complete synonymy, and reference to eleven authors who describe or figure it. The generic arrangement is essentially that of Lamarck with such modifications as the progress of science has rendered necessary. In the adoption of new genera proposed by later authors, the author has usually pursued a judicious course. Those genera which are founded upon sure, important, and identifiable characteristics, are for the most part received, while those founded upon trivial and uncertain points, indicative of groups of species merely, have been rejected. In the great family of Helicidæ, the species are so numerous that the temptation to adopt new generic distinctions is great, and a more advanced state of knowledge may perhaps justify such distinctions, but the author has wisely judged that our acquaintance with the soft parts of the widely varying species of this family is yet too limited to sustain even as subgenera the names proposed by Beck, Gray, Albers and others. An alphabetical index to the various genera, subgenera and synonyms mentioned in the catalogue greatly facilitates its use.

To amateur collectors the work may become specially useful for other purposes. By checking off upon it their own species, they become furnished with a catalogue of their own collections with little or no labor, and the printed sheets serve for very neat labels. The collection of Dr. Jay is arranged in the order of the catalogue, each specimen being numbered to correspond with it. Each species is placed upon a separate stand with a printed label, and all protected by glass. The whole affords an admirable model for the arrangement of natural history collections.

In spite of all the author's care, a few errors have crept in, but fewer than might have been expected in a work of so much detail. These we may hope will be corrected in the supplements which he may hereafter find it necessary to publish.

The work may be obtained from John Wiley, New York, J. B. Baillière, Paris, or from the author. J. H. R.

4. *A Synopsis of the Classification of the British Palæozoic Rocks;* by the Rev. Adam Sedgwick: *with a detailed Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge;* by Frederick McCoy, Prof. Geol. and Min., Queen's Coll., Belfast. Part 2, Palæontology, 184 pp. 4to, with 11 lithographic plates.—We learn in the preface that this volume is the first fasciculus of Prof. McCoy's Descriptive Catalogue of the British Palæozoic Fossils, placed by Prof. Sedgwick in the Woodwardian Museum. This part is devoted to the Radiata and Articulata. The second which is promised before the close of the year, will include the Mollusca and Vertebrata, and complete the series. The whole number of plates when completed will be 23. This extensive work is in the hands of one of the ablest Palæontologists of Great Britain, and is well executed. The number of new species and new genera is large, and if our limits did not forbid, we should take pleasure in transferring the descriptions of the added genera to our pages.

Prof. Sedgwick states in the preface, that the natural groups in the British Palæozoic series which will be recognized and illustrated in the work are as follows :—1. Hypozoic rocks; 2. Cambrian rocks (1, lower, below the Bala limestone, 2, upper, above the Bala limestone); 3. Caradoc group, which is not represented in Scotland and North England, but often overlies the Cambrian rocks unconformably in Wales and Shropshire; 4. Upper Silurian, including the beds from the Wenlock shale to the Tilestone; 5. Old Red Sandstone or Devonian; 6. Carboniferous; 7. Permian groups, which end the Palæozoic series, and are immediately followed by the Trias or New Red Sandstone.

Prof. Sedgwick expresses his thanks to the syndics of the university press, for bearing the expense of the letter press of this part of the work, but adds that it has not been brought before the public without much anxiety, and great personal cost.

5. *Monographie des Polpiers Fossiles des Terrains Palæozoiques précédé d'un Tableau Général de la Classification des Polypes;* by MM. Milne Edwards and Jules Haime. (Extrait du tome V dei Archives du Muséum d'Histoire Naturelle.) 502 pp. 4to, with 20 plates. Paris, 1851.—This work embraces a general review of the classification of zoophytes, a synopsis of all known genera, together with an elaboration of a large amount of new material, involving the institution of many new genera and many changes in the limits of those before established. The results are of the highest value to zoological science, although it may perhaps be questioned whether the farther study of the subject will sustain all the subdivisions. Connected with the extensive work on British fossil corals by the same author, published by the Palæontographical Society, these labors form the most extensive contributions to this department of Palæontology hitherto made. Besides these, other memoirs on zoophytes have been issued by the same authors in recent numbers of the Annales des Sciences Naturelles: and we may say truly that all the publications of Prof. Edwards, bear the impress of profound research. The plates are exquisite specimens of art and faithful delineations of the species.

The work is of great importance to the American geologist, as it includes descriptions of many species from the Palæozoic rocks of this country collected by M. de Verneuil. It also embraces species from all parts of Europe and from Great Britain, studied from specimens sent to the author for description by prominent geologists or by visiting collections. The whole number of species is about four hundred.

6. *Elements of Analytical Geometry;* by Albert E. Church, A.M., Prof. Math., in the U. S. Military Academy, West Point. Author of Elements of the Differential and Integral Calculus. 300 pp. 8vo, New York, 1851. G. P. Putnam.—There are many attractions in the branch of mathematics to which this work is devoted, and a beauty, clearness and brevity in its reasoning which recommend it for class instruction. The author states in his preface that while endeavoring to preserve the true spirit of analysis as developed by Biot, in his admirable work on the subject, he has made such changes in the arrangement of the matter and the method of demonstration, as he believed would render the whole more attractive and easily acquired by any student possessing a knowledge of the elementary principles of algebra and geometry.

7. *The Terrestrial Air-breathing Molluscs of the United States and the adjacent Territories of North America;* described and illustrated by AMOS BINNEY, edited by AUGUSTUS A. GOULD, vol. 1, 360 pp., 8vo, with 16 plates; vol. 2, 362 pp.; (vol. 3 not yet issued, to be a volume of plates.) Boston, 1851. Little and Brown.—These volumes are of the highest honor to the lamented author, both as a contribution to science and an example of private munificence seldom equalled. Near ten thousand dollars will have been expended on the work when completed: and the whole edition—290 copies—is reserved for distribution. As the title implies, the work treats of molluscs, and not simply of shells. In addition to the description of species, it takes up the anatomical structure of molluscs of the different genera, and illustrates this department by plates of unusual finish and minute accuracy; it treats of the habits and faculties of species; of their geographical distribution, and foci of origin, and of the introduction of those of foreign countries into the United States. It corrects largely the synonymy of the science showing numerous cases in which the names of Say and other American writers have been overlooked even to the present time, by European authors. The beautiful dissections and anatomical drawings of vol. i, are by Dr. J. Leidy of Philadelphia, who has contributed a chapter on the special anatomy of these molluscs.

The death of Mr. Binney was a sad loss to American science. As one of the founders of the Boston Natural History Society, as a contributor to its Journal and Museum, as the possessor of an extensive scientific library which he was constantly enlarging by the frequent addition of rare works, as a man of elegant taste as well as science, and as a friend of all that was good, he was held in honorable and grateful esteem in Boston, and in other parts of our land. These his last labors, just now open to the world, will secure for his name the widest distinction.

At the death of Mr. Binney, the publication of this work was left by his will in charge of Dr. Augustus A. Gould of Boston, and it could not have fallen into better hands. Dr. Gould has brought out the work in excellent style and has added to it many notes of value, besides giving it his critical supervision.

8. *History of Propellers and Steam Navigation with Biographical Sketches of the early Inventors;* by ROBERT MACFARLANE, C.E. New York: Geo. P. Putnam. 12 mo. pp. 144.—The object of Mr. Macfarlane's book is to furnish means of reference to inventors for a comparison of their schemes with similar contrivances already known or proved valueless. Much waste of time and means may undoubtedly be thus saved by a meritorious class of men whose efforts are frequently expended in a wrong direction. The book is illustrated by figures of various forms of paddle wheels, among which are the several forms proposed by Mr. Ewbank as modifications of the usual rectangular and fixed paddles now in use.

An interesting sketch of the history of ocean steam navigation forms the concluding chapter of the book.

9. *The Geological Observer;* by Sir HENRY T. DE LA BECHE, C.B., F.R.S., &c., Director general of the Geological Survey of the United Kingdom. London: Longman, Brown, Green and Longmans. 1851. 8vo. pp. 846.—This is not a reprint of the author's well known vol-

ume, "How to Observe Geology," long since out of print, though to a certain extent founded on the former treatise. Its object is to afford a general view of the chief points of geological science, such as existing observations lead us to infer to be firmly established in order to show how the correctness of such observations may be tested; and to sketch the directions in which they may apparently be extended. The great experience of the author as a "geological observer," the very Nestor of British geologists, his critical and cautious mind, his freedom from the distorting and partial bias of favorite hypotheses, all render him pre-eminently the man to present a true account of the present achievements of geology, and to indicate the course of study and observation required to advance it.

10. *Elements of Geology, intended for the use of Students;* by SAMUEL ST. JOHN, Prof. Chem. and Geol., in Western Reserve College. New York: 1851. 334 pp. 12mo.—This small work contains a brief review of the principles of the science of Geology illustrated with numerous wood-cuts, &c., well calculated to interest and instruct the student. Chapter first, treats of the general features and constitution of the earth, and the causes of change, atmospheric, aqueous and igneous: chapter second, of the structure and position of rocks; chapter third of fossils; fourth, of unstratified rocks; fifth, of stratified primary (metamorphic) rocks; sixth, of the Palæozoic system; seventh, of the secondary system; eighth, the tertiary period; ninth, the quarternary period; tenth, theoretical geology; eleventh, practical geology; twelfth, history of geology; thirteenth, relation of geology to religion; fourteenth, geographical geology. The subdivisions of the palæozoic rocks and the local geology of the United States are mentioned under the last head, and sections are introduced illustrating the subject.

11. *The Microscopic Anatomy of the Human Body in Health and Disease, illustrated with numerous drawings in color;* by ARTHUR HILL HASSALL, M.B., with additions to the text and plates, and an introduction containing instructions in Microscopic Manipulation, by HENRY VANARSDALE, M.D. 2 vols. 8vo., 1 vol. text, 560 pp. and one of 79 plates. First American edition. 1851. New York: Pratt, Woodford & Co. The importance of microscopic research in the study of the human system, is now very generally appreciated by medical men. The work by Mr. Hassall is intended to present some of the results arrived at by various recent observers in microscopic anatomy, both by descriptions and full illustrations. The first volume contains an account of the structure of the various constituent parts, fluids and solids, of animals, and the second volume gives representations of the same in lithography. The seventy eight plates contain on an average six figures each, and in general are well executed. The last ten plates have been added by the American editor; they are among the best in the volume. We may add to the credit of American skill, that the plates of this edition are in general decidedly better than those of the London impression. The work opens with an introduction prepared for this edition, containing much information on microscopes and their accessory instruments for dissection, injection, and other purposes, and on the preparation and preservation of objects. The instruments of the more prominent makers abroad are remarked upon with discrimination, and also the recent

labors of Spencer and others in this country. The volume is therefore highly valuable as illustrating the modes of microscopic research as well as the results of investigations, and especially so to the student of medicine.

12. *The Microscopist, or a complete manual for the use of the Microscope, for Physicians, Students, and all lovers of Natural Science, with illustrations;* by JOSEPH H. WYTHES, M.D., 191 pp. 12mo. Philadelphia, 1851, Lindsay & Blakiston. The recent multiplication of works on the microscope promises well for the future progress of American science. This little work is the third on the subject published in the country within the year past. It contains notices of different instruments, but is singularly deficient as an American work, in making no mention of the lenses of Canastota, which certainly are not surpassed in defining power by any abroad, and even take the lead of all others according to a report at the last meeting of the American Association. The volume contains descriptions of the microscope and its accompaniments, its modes of use, the methods of making preparations, and other information of importance to the young microscopist. We observe however, important deficiences and some errors; among the latter, a mixture of alcohol and water is spoken of as the basis of the Gannal process of preservation, instead of acetate of alumina; and the same objection is said to exist to the use of dilute alcohol, as to salt and water,—the objection to the latter, stated a few paragraphs above, being the development of a Confervoid vegetable.

13. *Report of the Special Committee in favor of a Geological Survey of California;* submitted by Mr. RANDALL, April 24, 1851.—This well-prepared report sets forth in a just light the importance of a geological survey of California. We observe the statement with regard to the yield of the gold mines, that for the last three quarters of the year ending Dec. 31, 1850, the amount was not less than $70,000,000; and for the first quarter of 1851, at the rate of nearly one hundred millions of dollars per annum.

14. *Graptolithes de Bohéme;* par JOACHIM BARRANDE, (Extrait du Système Silurien du Centre de la Bohème.) 74 pp., 8vo with 4 plates. Prague, 1850.—Numerous species are described and well figured in this memoir. The genera to which they are referred are Graptolithus, *Linn.*, and Rastrites and Gladiolites of Barrande. Some of the figures remind us very much of the stems with their seriate cells in the Sertularia tribe of polyps.

15. *Prof. Owen, F.R.S., on Dinornis*, Part iv, containing the restoration of the Feet of that Genus and of Palapteryx, with a description of the Sternum in Palapteryx and Aptornis. 20 pp. 4to. with 4 plates; from the Zool. Soc. Trans. vol. iv. Part 1. This important memoir is illustrated with excellent figures of the size of life.

16. *American Historical and Literary Curiosities, consisting of Fac-similes of original Documents relating to the events of the American Revolution, with a variety of Reliques, Antiquities, and Modern Autographs;* collected and edited by J. JAY SMITH and J. F. WATSON. Fifth edition, with additions. N. Y.: G. P. Putnam. 1852. 4to, pp. with 56 plates.—This is mostly a work of curious literary and historical interest relating to American affairs. There is a fac-simile of a let-

ter from the celebrated Robert Fulton with a sketch of his first steamboat. The letter is dated Sept. 26, 1802, from Paris, and in it he discusses the relative advantages of oars and paddles as a means of propelling a boat. Plate 28 gives a picture of John Fitch's steam-boat with his own description of the apparatus in the Columbian Magazine for December, 1786. A remarkable autograph letter follows under date of Dec. 25, 1790, in which he states that he gave his country this valuable invention on the 30th Aug., 1783, and had received no compensation. He adds, "another inducement which urges me to pursue this scheme is, to put it out of the power of future generations to make excuses for the present one—and if I should die in penury, want, wretchedness and rags, that my country may have no excuse, and that I may have the secret pleasure in the contemplation of receiving real pity from future generations." The work contains numerous titbits of scientific as well as general interest, mostly of a personal character.

16. *The Serpent Symbol, and the Worship of the Reciprocal Principles of Nature in America;* by E. G. Squier. 254 pp. 8vo. New York: 1851. G. P. Putnam. American Archæological Researches, No. 1.—Mr. Squier in his work on the Serpent Symbol, has brought his extensive Archæological knowledge to bear upon the history of primary religious ideas in the two continents. The work exhibits varied learning, and abounds in facts and suggestions that are of great interest. We are not prepared to admit however that they require or sustain the system of religious philosophy that pervades its pages. We should do the author however the justice to say that upon the main question, whether the resemblances in ideas between races is due to early connection or simply to identity of mental constitution, he observes that he would not express a preference for either hypothesis, much less decide between them; and if he has leaned to the latter, it has arisen from a desire to avoid the common error of attributing all coincidences and resemblances to intercommunication of races in periods more or less remote. Mr. Squier announces the following works of the Archæological series as prepared for publication, or as far advanced. 1. The Archæology and Ethnology of Central America. 2. The Mexican Calendar. 3. The Mythological System of the Ancient Mexicans. 4. The semi-civilized Nations of New Mexico.

Prof. J. W. Bailey: Microscopical Examinations of Soundings, made by the U. S. Coast Survey off the Atlantic Coast of the United States.—From the Smithsonian Contributions to Knowledge. 16 pp. 4to, with 1 plate.—Also Microscopical Observations made in South Carolina, Georgia and Florida.—Smithsonian Contributions to Knowledge. 48 pp. 3 pl. We have to defer a farther notice of these interesting memoirs to a following number.

Samuel L. Dana: A Muck Manual for Farmers; 3d edition, revised and enlarged. 346 pp. 12mo. Lowel and Boston: 1851.

M. Faraday: Experimental Researches in Electricity.—22nd series; Crystalline polarity of bismuth, antimony and arsenic, and on the magne-crystallic force.—23d series; On the supposed polarity of Diametric bodies.—24th to 27th series; On the possible relation of Gravity to Electricity.—On the magnetic and diamagnetic condition of bodies.—Magnetic conducting power.—Atmospheric magnetism.—From the Philosophical Transactions: No. 22, in the volume for 1849, 23, for 1850, 24–27, for 1851.

Report of the British Association for 1850. *London*, 1851.

Memoirs of the Geological Survey of the United Kingdom. Figures and descriptions illustrative of British Organic Remains, Decades I, II, III, 1849, 1850.

M. Adolph Wurtz: Memoire sur les Ammoniaques composées. (From vol. xi, of the "Memoires présentés par divers Savants à l'Academie des Sciences." 68 pp. 4to.

A. T. Kupffer: Annales de l'Observatoire Physique Central de Russie, publiées par ordre de La Majesté l'Empereur Nicolas I, sous les auspices de Mr. Le Comte Wrotchenko, Ministre des Finances et Chef du Corps des Ingenieurs des Mines. Année, 1847. No. 1 and No. 2. pp. 844 and 394, with numerous plates of diagrams.

R. T. Maitland: Descriptio Systematica Animalium Belgii Septentrionalis, &c., by Prof. J. van der Hoeven. Pars I. Animalia Radiata et Annulata. Large 8vo. xxxviii and 234 pp. Lugduni Bat. 1851. 1 *thal.* 26 *gr.*

Foerster: Monographie der Gattung Pezomachus. *Berlin*, 1851. Nicolai. 1½ *thal.*

Haeghens C. Martin and Berigny: Annuaire Meteorologique de la France pour 1851. 3d year. 1 vol. 8vo. 1851. 12 *fr.*

D. Dupuy: Histoire Naturelle des Mollusques terrestres et d'eau douce qui vivent en France. 4e fascicule. 4to. *Paris.* 10 *fr.*

A. D'Archiac: Histoire des Progrès de la Geologie de 1834 à 1849, published by the Geological Society of France. Vol. 3, in 8vo. *Paris.*

Violette and Archambault: Dictionaire des analyses Chimiques, or alphabetical Repertory of the analyses of all bodies, native and artificial, from the origin of chemistry to the present time. Vol. 2, in 8vo. *Paris.* 8 *fr.*

Fr. de Castelnau: Expedition dans les parties centrales de l'Amerique du Sud, &c., under the order of Government, between the years 1843 and 1847. History of the Voyage. Vol. 3. 1 vol. in 8vo. *Paris.* 7 *fr.* 50*c.*

A. Bertoloni: Flora Italica, vol. 7, Fasc. 5, large 8vo. 27½ *gr.*

Dr. A. E. Grube: Die Familien der Anneliden m. Angabe ihrer Gattungen u. Arten. Large 8vo. iii, and 164 pp. 1 lithog. *Berlin*, 1850. Nicolai. 1 *thal.*

Dr. A. Wagner: Beiträge zur Kenntniss der Säugethiere Amerika's. 3 abthl., arge 4to, 226 pp. and 7 lithog. 1851. 3⅓ *thal.*

Fr. Junghuhn: Plantæ Junghuhnianæ. Enumeratio plantarum quas in insulis Java et Sumatra detexit. Fasc. 1, large 8vo, 106 pp. Lugduni Bat. ⅔ *thal.*

Proc. Boston Soc. Nat. Hist., 1851.—p. 17. On Mollusca of Massachusetts Bay; *W. Stimpson*, (continued.)—p. 18. New genus and species of American Cottoids, Triglopsis Thompsonii; *C. Girard.*—On Swamps along western rivers; *Desor.*—Rutile of Waterbury, Vt.; *A. A. Hayes.—Feb.* 19. p. 25. On American Holothuridæ; *Mr. Ayres*, (Psolus levigatus.)—p. 26. Identity of Nucula navicularis and N. thraciæformis; *W. Stimpson.*—On the teeth of a Hippopotamus; *J. Wyman.*—*March* 5. p. 30. On the organs of vision and nervous system of the embryo of Ascidia; *C. Girard.*—On the cause of the want of symmetry in the curves of the earth's strata as seen in the mountain chains of Europe and America; *Prof. Rogers.—March* 19. p. 35. Structure of spinal cord in Bats; *J. Wyman.*—Holothuridæ, (continued); *Mr. Ayres.*—p. 37. A new Etheostoma, E. Linsleyi; *H. R. Storer.*—p. 39. Analysis of Pitchstone of Isle Royale and of phosphate of lime of Hurdstown, N. J.; *C. T. Jackson.*—p. 41. On Dunes on the shores of the Upper American Lakes; *Desor.*—p. 42. Strobilophaga enucleator abundant in March in Vermont.—*April* 2. p. 46. New genus of Holothuria, Stereoderma; *Ayres.*—p. 47. Analysis of phosphate of lime of Crown Point; *C. T. Jackson.*—An Ascidian, Pelonia arenifera, in Massachusetts Bay; *Stimpson.*—p. 49. Parallelism of the Quarternary deposits of Europe and America; *Desor.—April* 16. p. 52. New genus of Holothuria, Bothryodactyla; *Ayres.*—p. 56. Reports of Curator.—p. 59. Election of Officers, J. C. Warren, M.D., President; C. T. Jackson and D. Humphreys Storer, Vice Presidents; J. Eliot Cabot, Corresponding Secretary; Nath. B. Shurtleff, Treasurer; C. K. Dillaway, Librarian.—p. 60. A new Holothurian; *Ayres.—May* 21. p. 63. New species of Psolus, P. granulatus; *Ayres.*

Proc. Acad. Nat. Sci., Philadelphia.—July, 1851. p. 235. Fungous disease of Cicada; *J. Leidy.*—p. 237. Fossil ruminant ungulates from Nebraska Terr., (Oreodon (near Merycoidodon) priscum, O. gracile, Cotylops speciosa); *J. Leidy.*—p. 239. Helminthological Contributions, No. 3. (N. g. Synplecta and Myzobdella and several species); *J. Leidy.*—p. 244. New birds of the family Laniadæ; *J. Cassin.*—p. 247. New species of Grapsoid Crustacea; *J. D. Dana.*

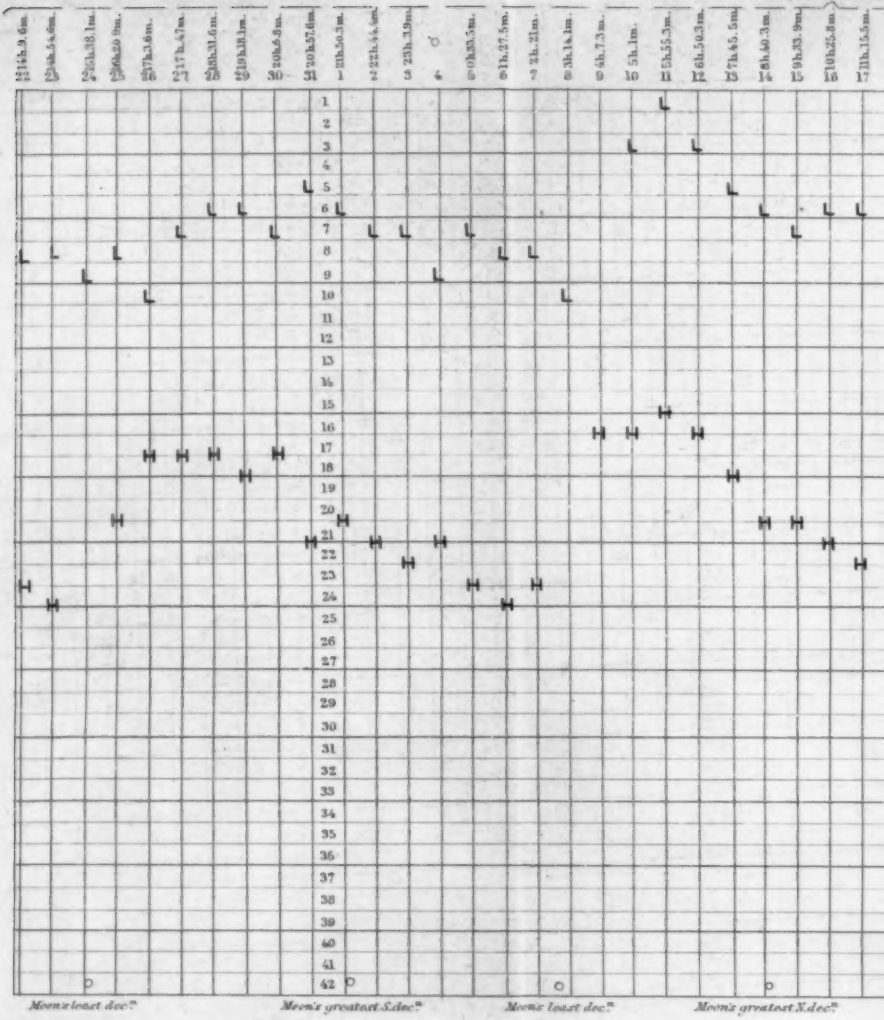
(H.No. 82)

U.S. Coast Sur

Tides at Cat Island Louisiana from the 22nd o

Rise and fall of tides from ho

Moon's Transits



The vertical lines represent one day

The space between the large horizonta

" " " " small "

(H No. 8)

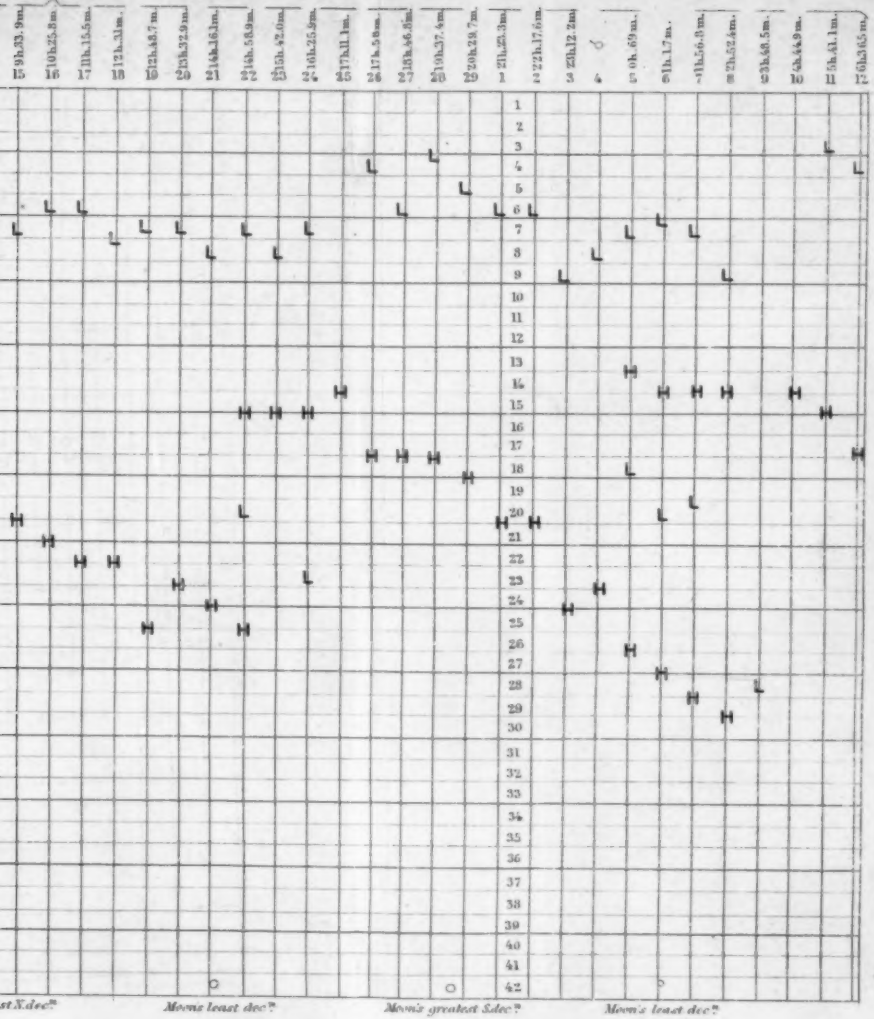
S. Coast Survey.

Plate 3

m the 22nd of January to the 12th of March 1848.

ides from hourly observations.

Moon's Transits



st N. dec.n Moon's least dec.n Moon's greatest S dec.n Moon's least dec.n

one day

ge horizontal lines represents 3 hours

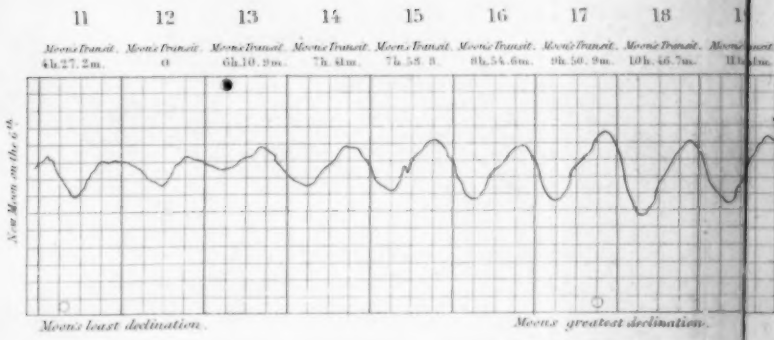
all " " " 1 hour

(H No. 7)

U.S. Coast Surv

Tides at Cat Island Louisiana from the 11

Curves of rise and fall of tides fro



The space between the large vertical lin

" " " small "

" " " " horizontal

(HN. 8)

Coast Survey.

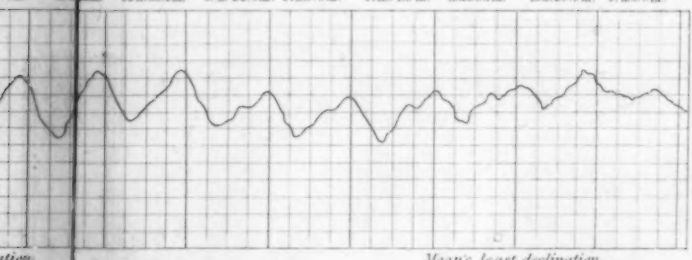
From the 11th. to the 26th. of January 1848.

of tides from hourly observations.

19 20 21 22 23 24 25 26

Moons Transit. Moons Transit. Moons Transit. Moons Transit. Moons Transit. Moons Transit. Moons Transit. Moons Transit.

7m. 11h.1m. 12h.33.1m. 13h. 22.6m. 14h.9.6m. 14h.54.6 m. 15h.36.1m. 16h.20.9m. 17h.3.9m.



ation.

Moons least declination.

ge vertical lines represents one day.

ll " " " 6 hours.

horizontal " " half a foot.

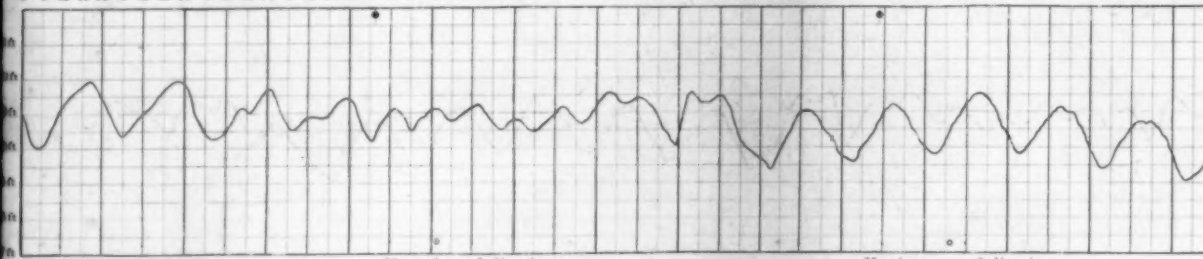
U

Tides at Cat

Curves of rise and

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	
Moon's Transit.	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon's Transit.*	*Moon*
21h.23. 3m.	22h.17. 6m.	23h. 12. 2m.	♂	0h. 6. 9m.	1h. 1. 7m.	1h. 58. 9m.	2h. 52. 4m.	3h. 48. 5m.	4h. 44. 9m.	5h. 47. 1m.	6h. 36. 6m.	7h. 30. 5m.	8h. 22. 4m.	9h

0 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6



Moon's least declination. *Moon's greatest declination.*

The space between

" "

" "

(H.No. 3)

U.S.Coast Survey.

...es at Cat Island Louisiana March 1843.

...f rise and fall of tides from hourly observations.

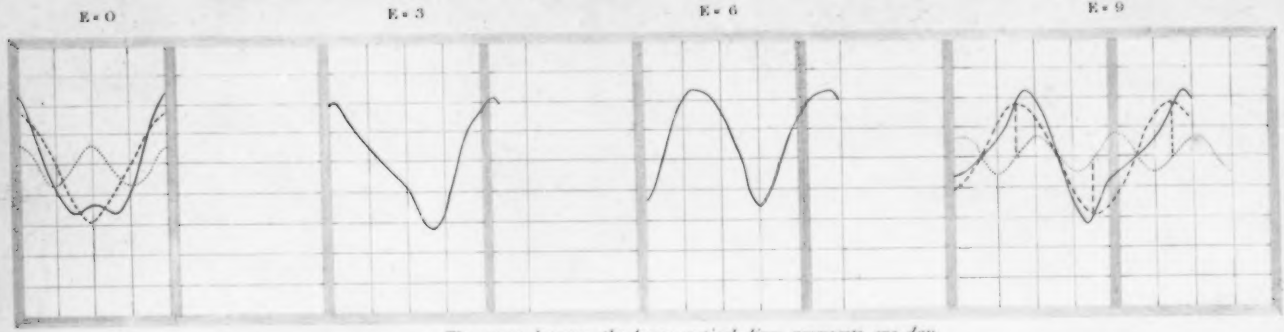
14th 15th 16th 17th 18th 19th 20th 21st 22nd 23rd 24th 25th 26th 27th 28th 29th 30th 31st

...Moon's Transit. 8h.22.4m. | Moon's Transit. 9h.12.2m. | Moon's Transit. 9h.59.7m. | Moon's Transit. 10h.45.4m. | Moon's Transit. 11h.29.6m. | Moon's Transit. 12h.12.8m. | Moon's Transit. 12h.55.7m. | Moon's Transit. 13h.38.7m. | Moon's Transit. 14h.22.3m. | Moon's Transit. 15h.6.8m. | Moon's Transit. 15h.52.7m. | Moon's Transit. 16h.40.1m. | Moon's Transit. 17h.29.6m. | Moon's Transit. 18h.19.3m. | Moon's Transit. 19h.10.8m. | Moon's Transit. 20.3.1m. | Moon's Transit. 20h.56.2m. | Moon's Transit. 21h.48.6m.

6 12 18 24 6 12 18 24 6 12 18 24

(HNo 4)

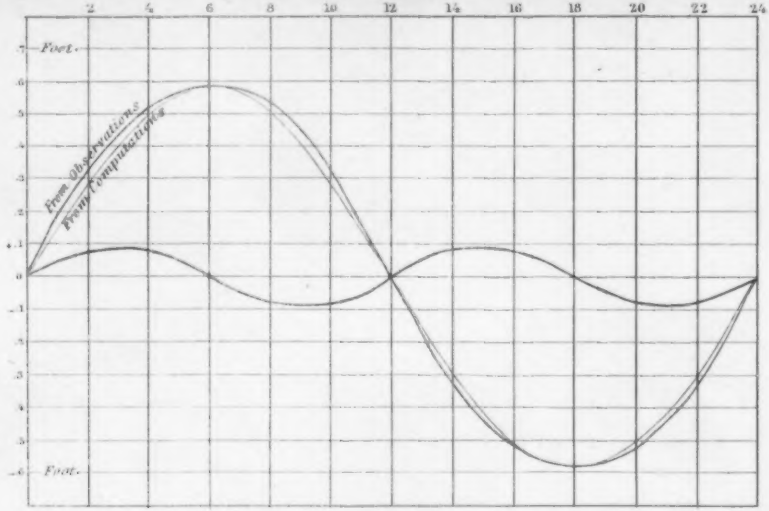
Forms of curves by interference for same values of C. & D. & E. for 0. 3 6. & 9 hrs.



The space between the large vertical lines represents one day
" " " " small " " " 6 hours
" " " " horizontal " " half a foot

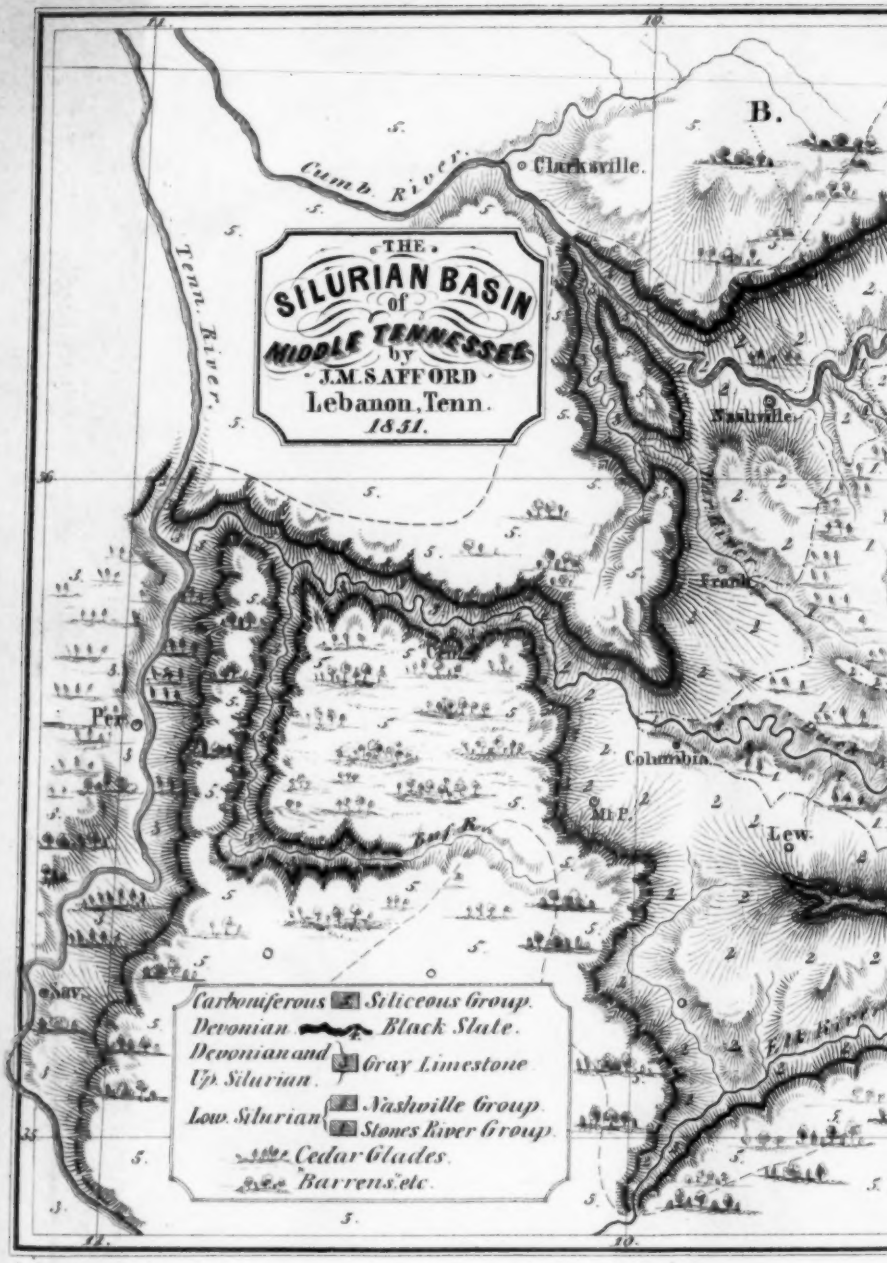
(H No. 5/8)

Mean curves for Jan. Feb. and Mar. deduced from observations & computations.

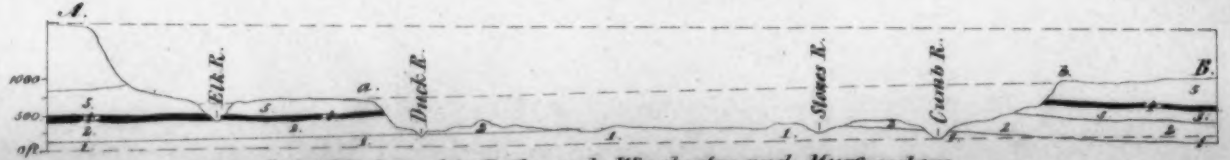


The space between the vertical lines represents 2 hours.

" " " " horizontal " " " $\frac{1}{10}$ of a foot.


THE
SILURIAN BASIN
of
MIDDLE TENNESSEE
by
J.M.SAFFORD
Lebanon, Tenn.
1851.
Cumb. River.
Tenn. River.
Clarksville.
B.
Nashville.
Franklin
Columbia
Pulaski
Lewisburg
Carbonuferous
Siliceous Group.
Devonian
Black Slate.
Devonian and
Up. Silurian.
Gray Limestone
Low. Silurian
Nashville Group.
Stones River Group.
Cedar Glades.
Barrens &c etc.

Lith. of Kich.d H. Pease Albany.



SECTION *from A to B. through Winchester and Murfreesboro.*

Index photographed at the
beginning for the convenience
of the microfilm user.